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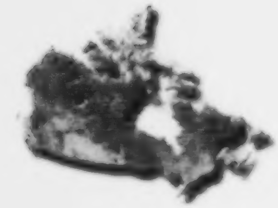

Field Sampling for Attributes Related to the Shelf Life of Mountain Pine Beetle-Killed Lodgepole Pine in the Sub-Boreal Spruce (SBS) Biogeoclimatic Zone

Jim Thrower[1], Jim Webb[1] and Dave Harrison[2]

Mountain Pine Beetle Initiative
Working Paper 2007–01

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Mountain Pine Beetle Initiative Project #8.38

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Executive Summary

In 2006, a total of 360 lodgepole pine (Pl) trees were destructively sampled from 45 sites that had been killed by the mountain pine beetle (MPB) over the last several years. These trees were sampled from the Sub-Boreal Spruce (SBS) Biogeoclimatic zone in Quesnel, Vanderhoof, and Burns Lake areas in north central British Columbia. The trees were distributed evenly across the geographic areas as well as across a sample matrix that included three classes of time since death, three classes of diameter at breast height, and three classes of soil moisture regime.

The sample trees were felled and bucked into 2.5 m lengths with stem analysis discs taken for detailed measurements of moisture content, checking characteristics, and blue stain content. Detailed measurements were taken on the trees prior to falling and on the site and stand conditions where the trees were sampled. Dendrochronology techniques were used to estimate the year of death of the MPB-killed trees, in addition to the subjective assessment of years since death estimated in the field.

This report describes the procedures to the collect the data and the associated database submitted to the Canadian Forest Service. The sample trees are summarized in the report, but this project did not include any analysis or interpretation of the data.

Résumé

Durant l'été 2006, on a coupé 360 pins tordus tués par le dendroctone du pin ponderosa sur 45 sites d'échantillonnage dans le centre-nord de la Colombie-Britannique. Ces arbres, tués au cours des huit dernières années, ont été sélectionnés dans des sous-zones biogéoclimatiques sub-boréales de l'épinette (SBS), dans les régions de Quesnel, Vanderhoof et Burns Lake. L'échantillonnage a été réparti uniformément dans la zone géographique, ainsi que selon un modèle comprenant trois catégories de temps écoulé depuis la mort, trois catégories de diamètre à hauteur de poitrine et trois catégories de régime hydrique du sol.

Les arbres sélectionnés ont été abattus et coupés en billes de 2,5 m de longueur. Des rondelles pour l'analyse de tige ont été prélevées afin de mesurer précisément le degré d'humidité et de contrôler les caractéristiques et le bleuissement. Des mesures précises des arbres ont été prises avant l'abattage et on a procédé à la description détaillée de l'état du site et du peuplement propres aux arbres de l'échantillon. Afin d'estimer l'année de la mort des arbres tués par le dendroctone, on a procédé sur le terrain à des évaluations subjectives du temps écoulé depuis la mort, puis à des appréciations plus rigoureuses au moyen de techniques dendrochronologiques exécutées en laboratoire.

Le présent rapport décrit la procédure suivie pour collecter ces données et établir la base de données connexe soumise au Service canadien des forêts et conservée par ce dernier.

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1. INTRODUCTION

1.1 BACKGROUND

British Columbia (BC) is undergoing one of the largest insect infestations in the recorded history of North America. This catastrophic infestation of the mountain pine beetle (MPB) has killed almost all mature lodgepole pine (Pl) trees in north-central BC and is currently attacking pure and mixed Pl stands in the southern interior. Early stages of the epidemic are now apparent in Alberta. One of the most important strategic issues relating to the infestation is the *shelf life* of the dead wood (i.e., how long the wood will remain in a condition where merchantable products can be recovered). The critical need for shelf life information has been identified in almost every report and study on the MPB issue in BC from the R&S Rogers report in 2001[1] to recently completed literature reviews in 2005 by Forintek[2] and Lewis and Hartley.[3]

Until recently, there have been few studies related to shelf life issues in BC. Some of the first research was initiated by Kathy Lewis and others at the University of Northern BC[4]. That work originally focused mostly on wood decay fungi and has expanded to include more of the attributes of interest for this project. The Council of Forest Industries (COFI) completed a study in conjunction with the BC Ministry of Forests and Range (MOFR) that sampled 109 MPB-killed red and grey attack class Pl trees from across the BC northern interior using similar methods to this project.[5] Several forest companies, universities, and industry cooperative agencies such as Forintek have completed or are in the process of completing proprietary and public domain research into the milling impacts of processing MPB-killed Pl logs. Most of the public domain research has been government funded and is reported on the web sites of the Natural Resources Canada, Canadian Forest Service (CFS) (mpb.cfs.nrcan.gc.ca/about_e.html) and the BC Government Forestry Innovation Investment (FII) program (www.bcfii.ca/industry_resources/mountain_pine_beetle.htm).

In an effort to provide additional information on the shelf life issue, the CFS initiated a project to collect data on a range of attributes using a specific sample matrix from a wide geographic area and from a range of site, tree, and stand conditions within the area impacted by the MPB. The intent was to collect data and examine the relationships between a range of potential predictor variables and several of these key attributes. The ultimate goal of this larger CFS project is to build mathematical models to predict some key attributes of trees, logs, and wood related to the shelf life of the MPB-killed wood for a range of different end products.

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[1] R&S Rogers Consulting Ltd. 2001. West central BC mountain pine beetle strategic business recommendations report. Contract report by R&S Rogers Consulting Ltd. for the BC MOF, Resour. Ten. and Eng. Br. Sept. 2001. 69 pp.

[2] Byrne, A., Stonestreet, C., and Peter, B. 2005. Current knowledge of characteristics and utilization of post-mountain pine beetle wood in solid wood products. Contract report by Forintek Canada Corp., Vancouver BC for NRCan, CFS, Victoria BC. MPBI Working Paper 2005-8. 18 pp.

[3] Lewis, K and Hartley, I. 2005. Rate of deterioration, degrade, and fall of trees killed by mountain pine beetle: A synthesis of the literature and experimental knowledge. Contract report by UNBC for the CFS MPBI program, Victoria, BC. 20 pp.

[4] Lewis, K.; Thompson, D.; Hartley, I.; Pasca, S. 2006 Wood decay and degradation in standing lodgepole pine (Pinus contorta var. latfolia Engelman.) killed by mountain pine beetle (Dendroctonus ponderosa Hopkins: Coleoptera) NRCan, CFS, Pacific Forestry Centre, Victoria, B.C. MPBI Working Paper 2006-11. 18 p.

[5] J.S. Thrower and Associates Ltd. 2005. A preliminary study of log and tree attributes related to the shelf life of MPB-killed Pl trees in the BC interior. Contract report to the Council of Forest Industries, Prince George, BC. Dec. 9, 2005. JST Project No. COF-002. 11 pp.

1.2 Goals & Objectives

The goal of the project was to complete the first phase of sampling to collect these data for the overall CFS shelf life project and research initiative. The specific objectives were to:

1. Update the 2004 sample plan.[6]
2. Field test the updated methods and make final modifications.
3. Sample 360 MPB-killed Pl trees across the range of conditions in the Sub-Boreal Spruce (SBS) biogeoclimatic zone according to the updated plan.
4. Complete field and lab measurements according to the updated plan.
5. Submit the final report (this document) and data to the CFS.

This project did not include any analysis or interpretation of the data. That will be done by the CFS and others after the data has been collected and documented.

The objectives of this report are to:

1. Document the project. Some details given in previous reports are not repeated here but are referenced where appropriate.
2. Provide background information on the data collection and measurements for subsequent analyses to be completed by the CFS.
3. Summarize the sample and some key attributes related to shelf life that will be of interest to subsequent analyses.

1.3 Terms of Reference

This project was completed by J.S. Thrower and Associates Ltd. (JST) for Natural Resources Canada, Canadian Forest Service (CFS), Victoria, BC. The JST project team was Jim Thrower, PhD, RPF (project manager), Jim Webb, BSc, FIT (field operations), Bruce McMahon, RFT (faller and cruiser), Shawn Corrigan (field assistant), Guillaume Therien, PhD (database and summaries), Craig Mistal, MPM, RPF (dendrochronology), Carlos Pinillos, MSc (database and cruise compilation), Alec Orr-Ewing, ATE, RFT (cruising technical support), and Margie Buhler (ring measurements).

This project was completed under Public Works Canada Contract No: 23145-060116/001/VIC from November 30, 2005 to November 30, 2006. The project was funded by the Government of Canada through the Mountain Pine Beetle Initiative (MPBI), a six-year $40 million program administered by the Canadian Forest Service. Publication does not necessarily signify that the contents of this report reflect the views or policies of Natural Resources Canada, Canadian Forest Service. Mention in this report of specific commercial products or services does not constitute endorsement of such by the Canadian Forest Service or the Government of Canada.

[6] J.S. Thrower and Associates Ltd. 2004. Sample plan to measure tree characteristics related to the shelf life of mountain pine beetle-killed lodgepole pine trees in British Columbia. Contract report to the CFS, Victoria, BC. MPBI Working Paper 2005-1. 17 pp. (available at http://bookstore.cfs.nrcan.gc.ca)

1.4 ACKNOWLEDGEMENTS

We thank the many industry contacts who helped us select sample sites including Earl Spielman, RPF (West Fraser, Quesnel), Stuart Parker, RPF (Fraser Lake Sawmills, Fraser Lake), Jason Regnier, FIT (Fraser Lake Sawmills, Fraser Lake), and Daniel Rollert, FIT (Babine Forest Products, Burns Lake). We thank Kathy Lewis, PhD for providing us with a master chronology for the Burns Lake area. We also thank Valerie Radley (Alcan Ltd., Burns Lake) and Alcan Ltd. for permitting us to sample trees on their private land along the Cheslatta River.

2. SAMPLE DESIGN

2.1 Development

The sample design and field methods used in this project were first developed in 2004 under a separate contract.[6] That plan was done in preparation for this and potentially subsequent field sampling by the CFS to help address the MPB shelf life issue. The main elements of the sample design remained relatively unchanged but some of the field sampling methods were refined (described in the next section). Refinements to the field methods were made largely on experience gained in completing a similar project for the Council of Forest Industries in the fall of 2005.[5] The updated sample and work plan was submitted to the CFS in March 2006 (Appendix 1).

2.2 Geographic Scope

Samples were distributed geographically according to the March 2006 sample and work plan. The sample trees were taken from the Sub-Boreal Spruce (SBS) biogeoclimatic zone in the Quesnel, Vanderhoof, and Burns Lake areas (Appendix 3). These general areas were selected to cover the main part of the SBS where samples of early red, late red, and grey attack trees could be taken from the same general area. These areas were also selected for easy access to roads and according to the suggestions of industry partners. Consequently, areas were not targeted where only one class of trees would be encountered (e.g., only grey or early red attacked trees) or areas that were far from roads.

This non-random selection of the trees is a biased sample. This bias was identified early in the design of this process and the risk of developing biased prediction equations was accepted by the CFS, given the high cost and practical impossibility of eliminating the bias.

2.3 Sample Matrix

The sample matrix was unchanged from the March 2006 plan. The samples were taken from the 3 x 3 x 3 matrix that included:

1. Time since death:
    a) 1-2 years since attack (early red attack) (attacked in 2005 or 2004).
    b) 3-4 years since attack (late red attack) (attacked in 2003 or 2002).
    c) 5+ years since attack (grey attack) (trees attacked in 2001 or earlier).

    The distribution of samples among these categories was approximate as they were based on field assessment. However, there is reasonably high confidence in these estimates based on the familiarity of local industry partners with the time of attack of many of the samples.

2. Soil moisture regime (SMR) relative to the BGC unit:
    a) Wet
    b) Mesic
    c) Dry

    Soil moisture was assessed visually based on the relative position of the site on the edatopic grid for the appropriate BGC unit. The soil moisture regime code was recorded instead of the broad class as indicated in the March 2006 plan.

3. Tree diameter (DBH):
    a) 12.5 – 22.5 cm
    b) 22.6 – 32.5 cm
    c) 32.6+ cm

2.4 Sample Size

The 360 sample trees were collected as indicated in the March 2006 plan originally. A much closer agreement in the distribution of trees across the matrix was delivered than had been anticipated. Less emphasis was placed on achieving the exact distribution in each of the three geographic areas to provide more flexibility in achieving the overall target distribution among the three dimensions of the sample matrix (Table 1).

2.5 Attributes of Interest

All attributes of interest were collected according to the March 2006 plan. Minor modifications were made to some attributes as indicated in Appendix 2.

Table 1. Sample matrix showing actual and target number of sample trees.

Sample Area and DBH Class	1-2 yrs since attack			3-4 yrs since attack			5+ yrs since attack			Total
	Wet	Mesic	Dry	Wet	Mesic	Dry	Wet	Mesic	Dry	
Quesnel										
12.5 – 22.5 cm	3/4	8/5	4/4	4/4	3/5	4/4	4/4	1/5	4/4	35/39
22.6 – 32.5 cm	4/4	4/6	9/4	5/4	5/6	6/4	6/4	11/6	11/4	61/42
32.6 cm+	2/4	2/5	0/4	3/4	3/5	0/4	4/4	6/5	4/4	24/39
	9/12	14/16	13/12	12/12	11/16	10/12	14/12	18/16	19/12	120/120
Vanderhoof										
12.5 - 22.5 cm	2/4	4/5	4/4	4/4	7/5	2/4	4/4	9/5	4/4	40/39
22.6 - 32.5 cm	4/4	8/6	2/4	6/4	6/6	3/4	3/4	5/6	1/4	38/42
32.6 cm+	5/4	6/5	4/4	2/4	6/5	6/4	4/4	5/5	4/4	42/39
	11/12	18/16	10/12	12/12	19/16	11/12	11/12	19/16	9/12	120/120
Burns Lake										
12.5 - 22.5 cm	6/4	3/5	4/4	4/4	6/5	6/4	4/4	5/5	4/4	42/39
22.6 - 32.5 cm	6/4	5/6	1/4	0/4	7/6	3/4	3/4	2/6	0/4	27/42
32.6 cm+	5/4	7/5	8/4	7/4	6/5	6/4	4/4	4/5	4/4	51/39
	17/12	15/16	13/12	11/12	19/16	15/12	11/12	11/16	8/12	120/120
Overall										
12.5 - 22.5 cm	11/12	15/15	12/12	12/12	16/15	12/12	12/12	15/15	12/12	117/117
22.6 - 32.5 cm	14/12	17/18	12/12	11/12	18/18	12/12	12/12	18/18	12/12	126/126
32.6 cm+	12/12	15/15	12/12	12/12	15/15	12/12	12/12	15/15	12/12	117/117
	37/36	47/48	36/36	35/36	49/48	36/36	36/36	48/48	36/36	360/360

3. FIELD SAMPLING

3.1 Refinements to Field Methods

The field sampling methods in this project were based on the updated March 2006 sample and work plan.[6] The methods that ultimately are reported in that plan were developed from experience gained working with West Fraser in 2004. Those preliminary methods are now reported in a CFS technical note.[7] Those methods were refined for the work completed for COFI in the fall of 2005.[5] The methods were again refined for the March 2006 plan completed under this project and then field tested in the first two days of field sampling (June 4 and 5, 2006). The minor changes required are described in this section and summarized in Appendix 2.

3.2 Field Crew

The field crew included Jim Webb (crew leader), Bruce McMahon (faller and cruiser), and Shawn Corrigan (assistant). Figure 1 shows the field crew with the addition of Esther Hsieh from Paprican who was with the crew on the last shift to test some new Paprican equipment (Section 3.11.1), and Carolyn Thorp who was with the crew for the entire project to collect data for a related project for the BC Ministry of Forests and Range (MOFR) (Section 3.11.2).

The core crew was maintained throughout the project. The original plan was to complete the sample with a two-person crew; however, the assistant was added after the first shift to increase productivity. Webb and McMahon also completed the selection of sample trees, fieldwork, and lab analysis for a similar project completed for COFI in the fall of 2005 that involved sampling 109 MPB-killed Pl trees from the Kamloops, Williams Lake, and Burns Lake areas.[5]

Figure 1. Field crew with the last tree of the project.

3.3 Fieldwork Schedule

The crew worked 10 day shifts. The first and last day of each shift was generally spent traveling from marshalling points of Kamloops and Vancouver. Sampling began on June 5, 2006 in Quesnel, continued in the area Vanderhoof (around Fraser Lake), and finished in Burns Lake (Table 2).

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[7] Harrison, D.S. 2006. Methodology to assess shelf life attributes of mountain pine beetle-killed trees. Canadian Forest Service Technology Transfer Note No. 35. Victoria, BC. Nov. 2006. 4 pp.

Table 2. Field crew shift schedule.

Shift	Date and Description of Work	
1	Jun 05 – 15	Sampled 31 trees from five sites in the Quesnel area.
2	Jun 21 – 29	Sampled 42 trees from seven sites in the Quesnel area.
3	Jul 05 – 14	Sampled 47 trees from five sites in the Quesnel area.
4	Jul 18 – 27	Reconnaissance of sites in the Vanderhoof and Burns Lake areas.
5	Aug 01 – 10	Sampled 49 trees from six sites in the Vanderhoof area.
6	Aug 15 – 24	Sampled 53 trees from six sites in the Vanderhoof area.
7	Aug 25 – Sep 01	Location of 138 trees in 17 sites in the Vanderhoof and Burns Lake areas.
8	Sep 05 – 14	Sampled 18 trees in the Vanderhoof area and 43 trees in the Burns Lake area.
9	Sep 19 – 29	Sampled 77 trees from 9 sites in the Burns Lake area.

3.4 Site Selection

The 360 sample trees were selected from 45 sites in each of the three general areas (Quesnel, Vanderhoof and Burns Lake) (Table 3). The sites and trees were subjectively located in conjunction with local industry partners and based on experience in selecting stands in other shelf life sampling projects. A map of the locations is given in Appendix 3.

Table 3. Geographic distribution of the 45 sample sites and 360 sample trees.

Location	Sites	Trees
Quesnel	16	120
Vanderhoof	14	120
Burns Lake	15	120
Total	*45*	*360*

The process was to identify a stand of trees that included a range of years since attack (early red, late red, and grey if possible), a range of DBH, and that had one general soil moisture regime (Figure 2). Sample trees were then located at the site using the target sample size in the sample matrix as a guide. If six or more trees were suitable for sampling according to the matrix, the site was selected. The 45 sites are summarized in Appendix 4.

3.5 Tree Selection

The sample trees were selected from the sites to fill the sample matrix while considering proximity to each other and safety for falling. Sample trees were selected from within an approximately 100 x 100 m (1.0 ha) area and from within two tree lengths from stand edges that had been open for more than one year. Some sample matrix cells were under-sampled geographically as the crew had difficulty locating them in the field; however, overall sample targets were achieved in most

Figure 2. Example of a stand selected with some late red and grey attack trees (Site 34 near Burns Lake).

cells. Some key descriptors are given for the 360 sample trees in Appendix 5.

Trees with obvious or significant defect, damage, or decay were not sampled. These trees created problems for cutting discs at consistent heights along the stem. Trees with minor damage that did not occur at the predetermined cutting height were selected at some sites if undamaged trees were not available. Where it was necessary to shift the height where discs were cut, this was done to best reflect the diameter and taper of the original location. This subjective selection results in a biased sample in regard to the occurrence of damage, which should be considered in subsequent analyses.

3.6 Site Measurements

Prior to felling sample trees, general measurements and description of the site included:

1. BEC classification (site series, soil moisture regime, and soil nutrient regime (visual estimates)).
2. UTM coordinates (from GPS).
3. Elevation (from GPS).
4. Slope and aspect.
5. Meso-slope position.
6. Digital photos of the stand.
7. General notes about the stand and history of MPB attack.
8. Weather conditions at the time of sampling.

3.7 Stand Measurements

Prior to felling sample trees, stand conditions were measured from a series of plots located in five point clusters. Four prism plots were located at 25 m on cardinal directions from the plot center (Integrated Plot Center (IPC)) and additional information was taken at the IPC. The clusters were subjectively located in the area where the sample trees were felled. The cluster configuration was modified in one case early in the project where sampled trees were sampled within a small area that was not suitable for this design. This is noted on the plot cards.

Information collected from this cluster included data for:

1. Large trees. Collected from the four prism plots (at the auxiliary locations) for trees > 12.5 cm DBH. These included two measure plots and two count plots.
2. Small trees. Collected from one 3.99 m radius plot located at each of the four prism plots for trees > 1.3 m in height and <12.5 cm DBH.
3. Regeneration trees. Collected from one 2.5 m radius plot located at each of the four prism plots for trees 0.3 - 1.3 m in height.
4. MPB-caused coarse woody debris. Collected from one 11.28 m radius plot located at the IPC.

A complete list of the attributes measured in these plots is given in the March updated sample and work plan. The data for each prism plot were entered and compiled in CruiseComp version 2006.01. These data and compiled results are included in the final database (Appendix 6).

3.8 Sample Tree Measurements

Measurements taken on each sample prior to falling included:

1. Height (tree length).
2. Diameter at breast height (DBH).
3. Presence of loose bark at breast height (BH).
4. Percent bark intact at BH and for tree.
5. Check length, depth and frequency in first 2.5 m log.
6. Pathological indicators (MOFR cards and standards).
7. Portion of foliage remaining.
8. Estimated years since attack (based on foliage and bark conditions, previous experience, and local knowledge).
9. Avian damage.

3.9 Falling & Bucking

After all data had been collected from the sample site and the standing sample trees, the trees were felled and bucked into 2.5 m sections (Figure 3). Stem analysis discs were then taken at stump height (0.3 m), BH (1.3 m above ground), at 2.5 m intervals from stump height, and at a 10 cm diameter top (inside bark). The sample resulted in 3,616 discs sampled from the 360 trees.

Figure 3. Bucking a sample tree into 2.5 m sections.

3.10 Increment Cores for Master Tree Ring Chronologies

Increment cores were taken from live Pl trees in the Quesnel and Vanderhoof areas to create master tree ring chronologies. These chronologies were used to provide known ring patterns and years to match with ring widths measured in the dead trees. The intent was to devise a better estimate of the year of attack and death than could be visually estimated in the field. For these chronologies, increment cores were extracted from 22 trees in the Quesnel area and 21 trees in the Vanderhoof area. Suitable live Pl trees could not be located on dry stressed sites in the Burns Lake area. These master chronologies and the dendrochronology analysis are described in more detail in Section 5.

3.11 Collaboration with Other Agencies

3.11.1 Paprican

Some stem analysis sample discs from grey attack stage trees were delivered to Paprican at various stages in the project. Paprican was interested in supplementing their sample of trees from older grey attack for analyses of fibre characteristics related to pulping.

Paprican was also involved at the end of this project. Esther Hsieh, BSc, from Paprican accompanied the field crew in the last shift to sites in the Burns Lake area to operationally test a new field spectrometer. Although those tests

focused on the spectrometer, the results did provide useful comparisons of moisture content and blue stain to those taken using the established methods. More detail on those comparisons can be obtained from Paprican.

3.11.2 British Columbia Ministry of Forests and Range

Additional data were also collected during this project for the MOFR. This was done in a cooperative effort between the CFS and the MOFR to extract additional value from this project. The data were intended to provide information on the correlation between externally visible indicators of log quality and internal characteristics related to shelf life. That work is not reported in this document.

To collect this data, a MOFR certified scaler was added to the crew. The data collection included calling the new MOFR interior scaling grades on the standing trees (in 5 m logs) prior to falling, then scaling the same 5 m logs with those grades after falling. This also included recording the number of quadrants visible on the standing trees with checks from BH to 30 cm below BH, and the depth of those checks. This last observation was made before and after stripping the bark below BH (Figure 4).

Figure 4. Falling tree 4 at site 1 in Quesnel.

4. DISC MEASUREMENTS

4.1 Overview

The original plan was to transport the stem analysis sample discs to the lab to complete measurements for moisture content (MC), blue stain, and checking. In the initial stages of sampling, however, it was discovered that additional drying and checking of the sample discs was occurring within hours of cutting. Consequently, MC measurements were taken in the field within one hour of falling and cutting the discs (Figure 5).

The other measurements were performed within two or three hours of falling. The discs were protected from sun and rain prior to taking the measurements to minimize additional drying or checking. Ring width measurements on the BH discs and the increment cores (taken to create a master tree ring chronology) were the only measurements taken in the lab. Those methods are described in the next section.

Figure 5. Taking disc measurements in the field.

Measurements taken in the field included:

1. Diameter outside bark (DOB).
2. Bark thickness and percent intact.
3. Moisture content (MC).
4. Check azimuth, depth, width, and pattern.
5. Blue stain width, degree, and pattern.
6. Decay type, location, and extent.

4.2 Demarcating Discs

The north, east, south, and west azimuths were marked on each disc (Figure 6). These marks were referenced from the line painted along the bole of each tree after falling. This line was extended from the north line painted at the stump and at breast height on each tree prior to falling. These cardinal direction reference marks were used in the measurements of checks, MC, and blue stain.

4.3 Diameter & Bark thickness

The DOB was measured on each disc using a steel diameter tape. Where bark was loose and could be reconstructed on the disc, it was included in the DOB and average bark thickness measured and recorded at the same time. If the bark was not fully intact and could not be reconstructed, the proportion (%) of bark intact was estimated and recorded.

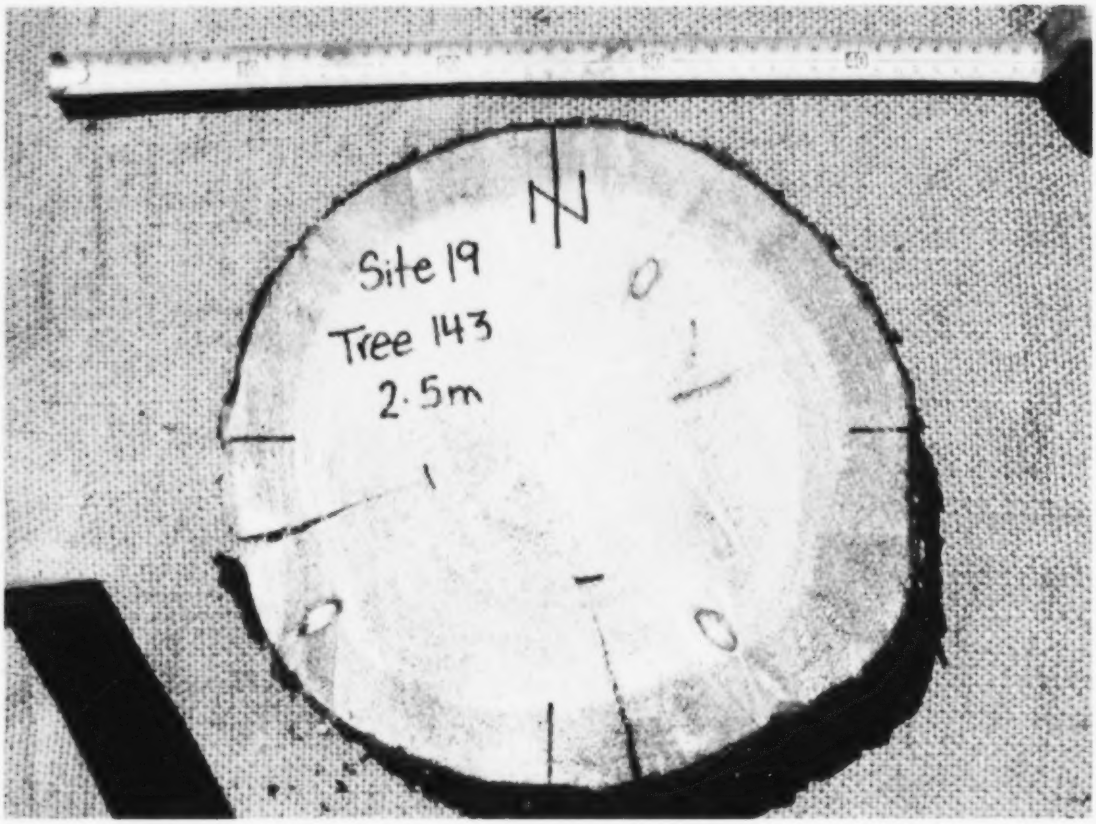


Figure 6. Sample discs showing marks for quadrants based on cardinal directions and at the bottom of each check.

4.4 Moisture Content

4.4.1 Disc Measurements

MC measurements were taken with a Delmhorst J-2000 moisture meter (www.delmhorst.com) (Figure 7). This meter is widely used in log yards and sawmills in the BC forest industry and is considered accurate and durable.

Nine MC measurements were taken on each disc: at the pith and in the middle of the sapwood and heartwood at each cardinal direction. The point of measurement was moved where needed to avoid knots. The MC measurements were checked periodically throughout each shift using a second Delmhorst J-2000 meter. The MC measurements between the two meters were consistently within 1.0%.

4.4.2 Oven-Dry Comparisons

The MC estimates from the meter were compared with oven-dry estimates. A total of 14 discs were selected periodically throughout


Figure 7. The Delmhorst J-2000 moisture meter.

the project and a small sample of wood was removed. The samples were then weighed immediately (accuracy of 10 milligrams) and MC estimated using the meter on each of the four sides and the two ends of the sample (Figure 8). The six MC readings were averaged to give one estimate for each sample. At the end of field sampling, the samples were oven-dried at 40°C for one week and computed the MC was computed using the oven-dry weight.

Figure 8. Weighing wood samples to estimate MC from oven-dry weight.

The comparison showed the two Delmhorst meters under-estimated the oven-dry MC by 2.1% and 2.4%. The database submitted with this report includes only the measurements from the meter. Adjustment to MC for these differences can be made to those original measurements in subsequent analyses if required.

The MC readings from the meters were always lower on the upper and lower surface of the small samples of wood from the discs. This could be caused by drying in the time between cutting the discs and measuring the MC of the sample. When readings from the upper and lower surface are excluded from the comparison with field readings, the meters under-estimate oven-dry MC by 3.1% (3.2% and 3.0% for the two meters). When the two samples with MCs between 35% and 40% (the upper limit of the meter) are excluded, the meters under-estimated oven-dry MC by 1.1% and 1.0%. The data for these oven-dry comparisons are given in Appendix 7.

4.4.3 Paprican Comparisons

Paprican estimated oven-dry MC on a small sample of discs taken in the last shift of the project. This was done in the lab from samples stored in plastic bags during transportation. From that comparison, Paprican estimated that the meters appeared to under-estimate MC by 4% to 5%. Although Paprican's samples received different handling, their results do suggest that the meters may have under-estimated oven-dry MC. Any adjustments to the MC given in the database from this project can be made considering these results.

4.5 Check Measurements

The extent of each check was marked with a felt pen immediately after falling and prior to the discs being bucked (Figure 6). This mark ensured that the recorded measurements did not include additional checking that could have occurred after falling and handling. The measurements included check width (at cambium), depth (from cambium), azimuth (from the pith), and pattern (straight, curved, doglegged, splintered).

4.6 Blue Stain

Blue stain measurements were recorded by quadrant (Figure 6). The measurements included average width of the stain, degree of stain (light, medium, dark), proportion (%) of area stained in the width measured, and pattern of stain (solid or patchy).

4.7 Decay

Decay was measured on each disc using the MOFR procedures for net volume adjustment factor (NVAF) sampling. This included using the tip of a knife to check fiber strength and determine the location and extent of suspected decay. Measurements included location of the decay (sapwood, heartwood or both), type of decay (if known), and affected area (cm^2).

4.8 Photographs

Photographs of each disc were taken in the field with a 6.0 mega pixel digital camera (Canon A540). A steel measuring tape was included in each photo as a scale (Figure 6). Most images were taken at the sample site when natural light was adequate, or at roadside in lower light conditions. A wooden stand with two fixed heights was used to maintain a constant height from the camera to the disc. The taller height was used for large discs and the lower height for smaller discs.

5. DENDROCHRONOLOGY

5.1 Purpose

One of the most important attributes for consideration in subsequent analysis of these data is the number of years since the sample trees were attacked and killed by the MPB. The field crew estimated this *time since death* in the field using visual indicators (e.g., foliage, bark, and branch condition), experience doing this work in other projects, and the local knowledge of industry partners, who often had clear recollection of when individual trees were attacked. To improve the reliability of these estimates, dendrochronology was used to more precisely estimate the number of years since death.

5.2 Sample Trees

To create the chronologies, 22 increment cores were taken from live, stressed Pl trees growing on dry sites in the Quesnel area and 21 cores in the Vanderhoof area. Suitable live trees were not found in the Burns Lake area. The Quesnel cores were taken from sites east of town and along West Fraser's 1300 Road in TFL 52. The Vanderhoof area cores were taken north of Fraser Lake from a site along the Shovel-Sutherland Forest Service Road.

5.3 Ring Width Measurements

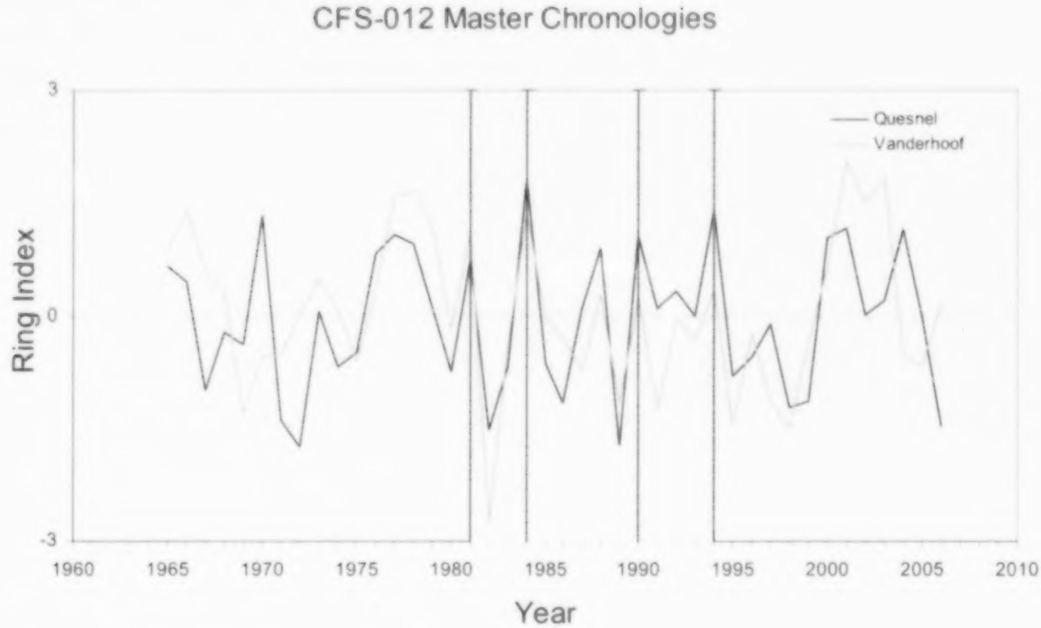
The tree ring widths were measured on the increment cores and on the BH discs taken from each sample tree using a Velmex tree ring measuring system (www.velmex.com) (Figure 9). Two radii on each BH disc were measured to provide a comparison for error checking, and also to help identify missing rings. The discs and cores were kept in cold storage until they were measured in the company's Kamloops lab.

Figure 9. Measuring growth rings with the Velmex.

5.4 Master Chronologies

Three master tree ring chronologies were used: one for the Quesnel area created from the samples, one for the Vanderhoof area created from the samples, and one for the Burns Lake area provided by Kathy Lewis (UNBC). Chronologies were built using the 2006 growing season as the final year.

In the last 30 years, the years 1981, 1984, 1990, and 1994 were identified as common among the three chronologies (Figure 10). These similarities gave confidence in the master chronologies from the cores as the UNBC master chronologies had been cross-dated.



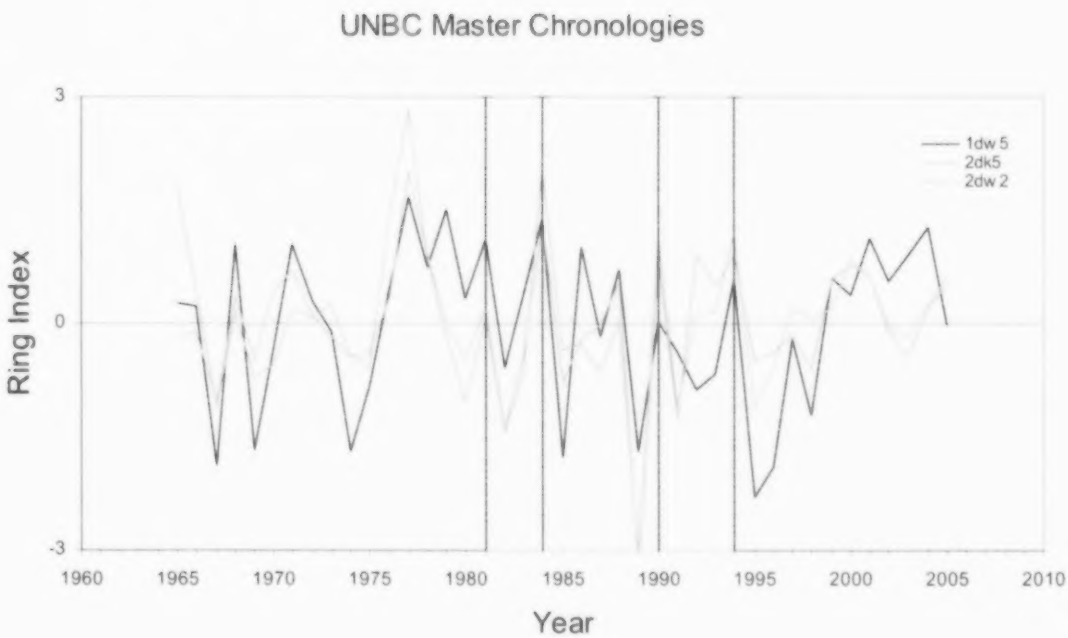


Figure 10. Master chronologies from the Quesnel and Vanderhoof areas (above) and from Kathy Lewis at UNBC. Markers years of 1981, 1984, 1990 and 1994 are shown on both chronologies. The UNBC graph shows master chronologies for Pinchi Mountain (1dw5), Greer Mountain (2dk4), and the Holy Cross Road (2dw2).

5.5 ANALYSIS

To estimate the most likely year of death, COFECHA software (www.ltrr.arizona.edu/software.html) were used to compare the standardized ring width patterns for each BH disc to the master chronologies. Disc ring indices were broken into 30-year segments with 15-year lags and cross-dated to the master chronologies. Graphical comparisons based on standardized ring widths (Figure 11) were also made, to help validate the COFECHA output.[8]

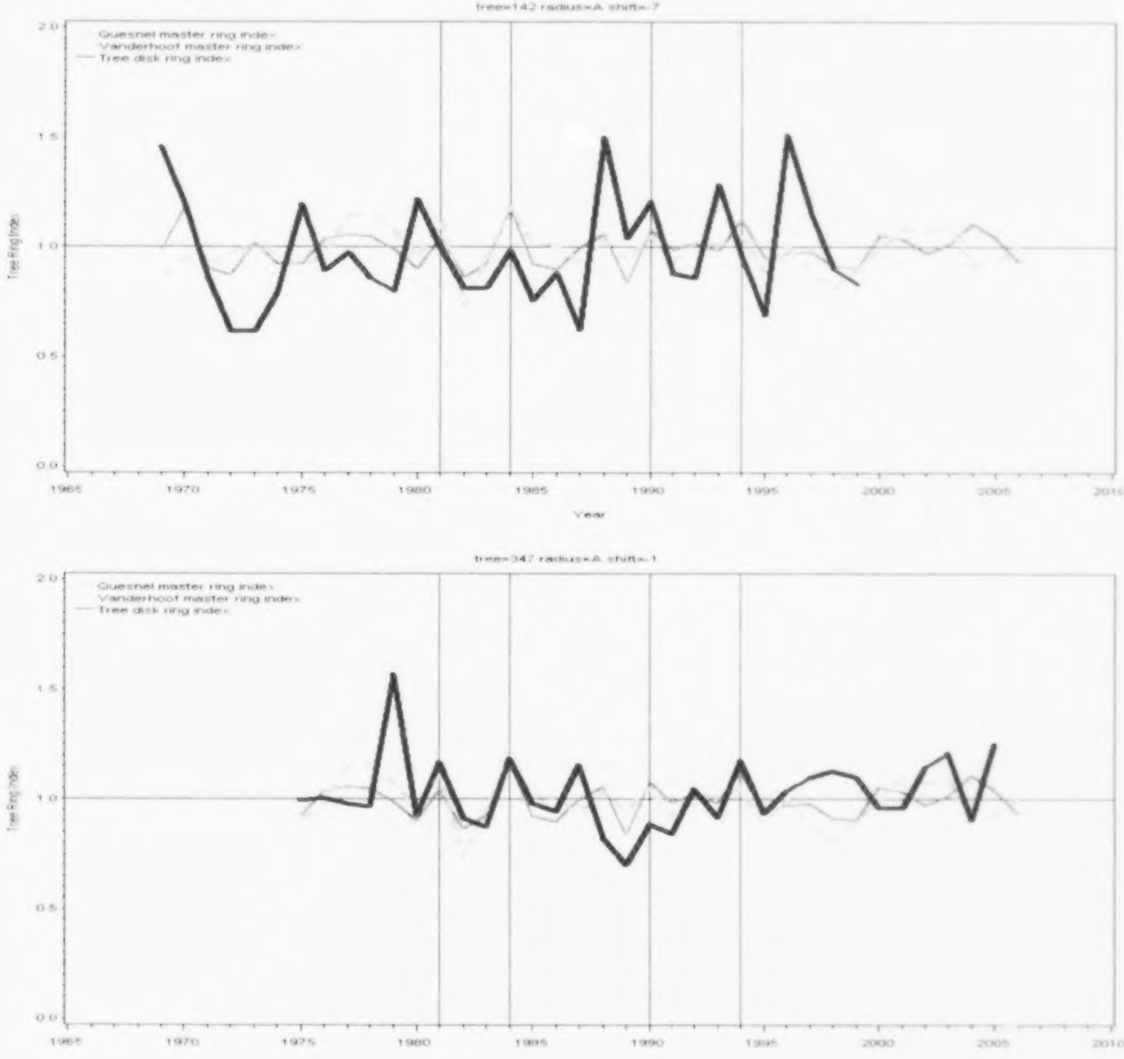


Figure 11. Dendrochronology graphs showing tree 142 with a poor correlation to the master chronologies (above) and tree 347 with a strong correlation to the master chronologies (below). Marker years (rings) are indicated by vertical lines.

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[8] Graphical comparison is recommended by *Grissino-Mayer, H.D. 2001. Research report evaluating crossdating accuracy: A manual and tutorial for the computer program COFECHA. Tree Ring Reseach Vol. 57 No. 2.*

Figure 11 shows an example of a weak and a strong correlation between the COFECHA output and the Quesnel and Vanderhoof master chronologies. In the poor correlation, visual comparison shows poor correlation with most of the marker ring peaks from the tree and the master chronologies. In contrast, the higher correlation comparison shows much closer correspondence between the disc patterns and the master chronologies, where almost all marker years match with the tree.

For trees 1 to 120, the Quesnel master chronology was used and for trees 121 to 360 the Vanderhoof master chronology was used. If chronologies for an area did not match well with sample tree rings and an illogical year of death was generated, other chronologies and index years were tested for higher correlation.

The results from the dendrochronology analyses, including comments on the reliability of the estimated year of death, are in the database. In some cases, the dendrochronology analysis (COFECHA and graphical comparison) could not estimate a reasonable year of death. This is noted in the database and subsequent analysis of the data should carefully consider which estimates of years since death to use. More detailed dendrochronology analysis should also be considered in subsequent analyses of the data.

6. DATA MANAGEMENT

6.1 Data Entry

All data collected in the field were entered by the field crew during the project as time permitted. The remaining data were entered by the field crew immediately after the fieldwork was completed. All data were entered and checked by the end of October 2006.

6.2 Back-up

During the project, plot packages were photocopied and stored in the company's Kamloops and Vancouver offices at the end of each shift. Each day, plot packages were stored in a safe location with the crew. Digital images were backed-up daily on the field laptop computer and on an external hard drive.

6.3 Quality Assurance

The data were checked continually during the data entry process and after all data were entered. A final audit was done by randomly selecting and fully checking the data from three sites from each of the two people who entered the data. All data from these sites were checked against the plot cards. The audit for one individual yielded no errors. The results for the other person showed some small errors, and thus all data entered by that person were checked against the plot cards. This was completed by the end of October 2006.

6.4 Database

A custom database for this project has been developed in MS Access™. The database contains 13 related tables with keys linking tables including site number, tree number, cookie (disc) number, or plot (cruise) number. This database is submitted to the CFS with this final report and described in Appendix 6. In the database, tree *discs* are referred to as *cookies*.

Subsequent analyses will require building custom queries to extract data from the various tables in the specific format and sequence required.

7. SUMMARY OF SAMPLE TREES

The sample trees were selected to achieve the distribution targeted in the sample matrix (Table 1). The resulting sample is balanced as planned across the three main attributes of years since death, DBH, and soil moisture regime. Table 4 shows the distribution of the 45 sites and 360 trees by narrower classes than used in the sample matrix. Graphs of the some key attributes related to the shelf life of MPB-killed Pl are given in Appendix 8.

Table 4. Distribution of sample sites and trees by some key attributes.

Attribute	Number and Proportion of the 45 Sites		Number and Proportion of the 360 Trees	
Years Since Attack				
1	17	38%	58	16%
2	20	44%	62	17%
3	27	60%	77	21%
4	18	40%	43	12%
5	24	53%	72	20%
6	15	33%	41	11%
7	3	7%	7	2%
DBH Class (cm)				
15	11	24%	21	6%
20	26	58%	94	26%
25	28	62%	79	22%
30	29	64%	48	13%
35	29	64%	94	26%
40	11	24%	20	6%
45	2	4%	2	1%
50	1	2%	2	1%
Moisture Content				
10%	5	11%	11	3%
15%-	21	47%	52	14%
20%	34	76%	79	22%
25%	29	64%	52	14%
30%	26	58%	54	15%
35%	25	56%	43	12%
≥40%	24	53%	69	19%
Remaining Foliage				
0%	23	51%	60	17%
1-10%	30	67%	85	24%
11-50%	30	67%	92	26%
≥51%	27	60%	123	34%
Foliage Class				
Early Red	26	58%	120	33%
Late Red	31	69%	120	33%
Grey	30	67%	120	33%
Soil Moisture Class				
Dry	12	27%	108	30%
Medium	18	40%	144	40%
Wet	15	33%	108	30%

8. RECOMMENDATIONS

8.1 Field Procedures

8.1.1 General Methods

The field procedures and methods used in this study worked very well. These methods were the result of three different operational tests, each followed by updates and modifications. These methods were originally developed for the shelf life sampling that was completed for West Fraser. Those methods were modified and refined for the work completed for COFI. Those methods were modified again and refined for this project, which were subsequently tested in the first few days of field sampling and refined again. As expected, there is always an opportunity to improve all aspects of project planning and execution, and other practitioners may find better or more efficient methods than those developed here.

8.1.2 Crew Training

The success of completing the field work on time, on budget, and to a high degree of quality, consistency, and safety was due entirely to having a highly trained and competent field crew. The main members of the crew (Webb and McMahon) had worked on the COFI project prior to this project, and were involved in the modification to those and the previous sampling methods. They were entirely familiar with the measurement procedures and standards of precision required. Without that previous experience, and an inherent attention to detail, considerable additional training would have been required. Any subsequent field sampling done using these or similar methods must include careful selection of crew members and a significant training component to ensure operational collection of data is done consistently and with a high degree of precision.

8.1.3 Crew Logistics

The field crew developed an optimal mix of site reconnaissance and field sampling. What works for one crew may not work for another. For some crews, an efficient method may be to separate field reconnaissance from sampling. Reconnaissance work with a full crew was found to be an ineffective use of resources. At stages through the project, a reduced crew of two located most of the sites, identified sample trees and did initial standing tree measurements. This improved productivity when the full crew returned for destructive sampling. With a smaller crew, such as two persons, completing reconnaissance and sampling at the same time would be more productive.

8.1.4 More Detailed Attributes

The attributes selected for measurement in this project were considered carefully by the CFS during the planning phases of this project. The trade-off is always fewer samples with more detail, or more samples with less detail. Some researchers requested more detail on some attributes; however, the decision was made by the CFS to limit the amount of information that was collected on each tree to allow for the sampling of more trees. A consideration for future sampling may be to sub-sample trees for more detailed measurements. Special studies could also be done to link the more detailed attributes with the more extensive and larger sample.

8.2 Data Analysis

8.2.1 Scope of Inference

These trees were subjectively selected and thus are a biased sample of the larger population of MPB-killed Pl trees that they are intended to represent. Theoretically, this restricts the statistical scope of inference of the data to these trees only. Extrapolation of the results of analyses of these data requires the assumption that these sample trees accurately represent (i.e., are an unbiased sample) all of MPB-killed Pl trees with similar attributes in the area of application (e.g., all of the SBS). This is probably a reasonable assumption in most cases; however, analysts must

be aware of this assumption and consider it in their interpretations. Specific considerations in assessing the appropriate scope of inference are:

1. The sample sites within the targeted broad geographic areas were subjectively located.
2. The sample trees within those sites were subjectively located to fill the target sample matrix.
3. The sample trees were subjectively selected to avoid obvious external damage.

8.2.2 Care and Due Diligence

A high degree of care and due diligence is required when analyzing these data. The field procedures to collect the data and the database have been carefully described; however, there are many opportunities to misinterpret the data, expansion factors, or confuse data fields. It is strongly suggested that researchers carefully read these methods before starting analysis. Failure to use the correct field will result in embarrassment for all involved.

8.2.3 Dangers of a Chronosequence

Analyses of these data that examine trends over time assume a chronosequence. This assumes the data are linked from one year to another. This is not the case as the trees in one age class are not the same as in another. This means that analyses examining trends over time (years) since death must assume that they are linked. This is probably reasonable in most cases; however, analysts must be aware of this assumption and consider it when interpreting results of analyses. Analysts should examine every possibility to test or hypothesize why this assumption may not be true.

An example of where the chronosequence assumption may be misleading was shown in a recent analyses of shelf life data. The analysis showed a clear trend where the proportion of blue stain was lower in trees with more years since death. The interpretation implied in the chronosequence assumption is that blue stain decreases over time. This is not true. A likely explanation is that the level of MPB attack in recent years was heavier, thus the amount of inoculum and associated blue stain was also heavier than in the trees that were attacked years ago. If the same trends were examined in linked data (i.e., in the same trees), this result would never have been observed.

8.2.4 Moisture Content

The database includes the moisture measurements as recorded from moisture meters (Section 4.4). As noted in the report, the meter readings differ slightly from those of the oven-dry tests and from the Paprican comparisons. Accordingly, future analysis using these moisture content measurements should reflect the minor variations observed between the different tests.

8.2.5 Years Since Death

The number of years since death will be an important attribute in all analyses of these data, and *time* will be used in almost all applications of the results. Unfortunately, estimates of time since death – from the field and from dendrochronology analyses – are only approximate.

It had been expected that the dendrochronology techniques would have produced more certain estimates of the year of death, but that was not the case. In several instances, there were fairly strong results from COFECHA that did not make sense when compared to the field estimates. A descriptor was included in the database of the degree of confidence in the COFECHA results, which should be considered by future analysts. It is recommended that the field estimates of time since death be used when the COFECHA estimate is weak. Consequently, the number of years since death should be described using a combination of the two estimates.

8.3 Future Sampling & Refining the Sample Matrix

The intent of the CFS in the initial planning stages of this project was to expand this sample to include more trees from a wider geographic area (e.g. other BEC zones). Before that is done, analyses will need to be completed to statistically test the significance of the attributes included in the sample matrix.

The sample matrix was developed to include attributes, and classes for those attributes, which are believed to be related to shelf life characteristics. However, subsequent analyses may show that some of these attributes are not well related to shelf life attributes and probably should not be part of future sampling efforts. For example, analyses may not show any statistical difference between patterns of checking or wood moisture content (MC) and the soil moisture regime (SMR) of the site. Thus, the sample matrix could exclude site SMR in future samples.

Conversely, analyses may show a relationship between attributes that were not included in the sample matrix and shelf life characteristics. Indeed, analyses could show a relationship between aspect and the rate of drying. If so, aspect could be considered for including in the matrix for future sampling.

APPENDIX 1 – SAMPLE DESIGN AND FIELD METHODS USED

Sample and Work Plan
For Shelf-Life Sampling in the SBS

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CFS MPBI Project 8.38

March 23, 2006

Preface

This sample and work plan were prepared as part of a project being completed by J.S. Thrower & Associates Ltd. (JST) for the Department of Natural Resources, Canadian Forest Service (CFS) in Victoria, BC. The JST team managing this project is Jim Thrower, PhD, RPF (project manager) and Jim Webb, BSc, FIT (field operations).

This sample and work plan is intended to guide the field operations of the shelf life project. This document may be modified during implementation of the project to reflect changes.

SAMPLE DESIGN

Overview

The samples in this project are individual trees purposively selected from a 3 x 3 X 3 matrix within the Sub-Boreal Spruce (SBS) biogeoclimatic zone. The target is to sample 360 lodgepole pine (Pl) trees across the sample matrix that includes: 1) time (yrs) since trees were attacked by the mountain pine beetle (MPB) (three classes); 2) tree diameter at breast height (three classes); and 3) soil moisture condition (three classes).

Measurements will be taken from: 1) sites where the trees are sampled; 2) trees prior to falling; 3) trees after falling; 4) discs cut from 2.5 m intervals from the fallen trees; and 5) live Pl trees on stressed sites in the general geographic area to establish a master tree ring chronology by which the age of the dead trees can be determined.

Geographic Scope

The sample will be taken from the SBS biogeoclimatic zone only (samples will be taken by the CFS from other biogeoclimatic zones in future phases of this project). The intent is to distribute the samples across the range of the SBS where we can sample a range of time since death. Given the history of where the MPB infestation started and how it has progressed through the SBS, this will include the general geographic areas around Burns Lake, Vanderhoof, and Quesnel. The exact locations of the sample trees will be determined in the reconnaissance phase of field sampling.

Sample Unit

The sample unit is individual trees.

Sample Matrix

Samples will be taken from a 3 x 3 x 3 matrix (response surface) that contains 27 cells:

1. Time since death:
   a) 1-2 years since attack (red attack) (attacked in 2004 or 2005).
   b) 3-4 years since attack (red attack) (attacked in 2002 or 2003).
   c) 5+ years since attack (grey attack) (trees attacked in 2001 or earlier).

   The distribution of samples among the three categories of time since death will be approximate, because the actual time since death will not be known until the dendrochronology analyses is completed. To improve estimates of time since death in field sampling, dendrochronology analysis will be completed on an initial set of samples during the beginning of the field sample phase.

2. Soil moisture regime (SMR) relative to the biogeoclimatic unit:
   a) Wet
   b) Mesic
   c) Dry

   Soil moisture will be assessed visually based on the relative position of the site on the edatopic grid for the appropriate biogeoclimatic unit relative to mesic sites.

3. Tree diameter (DBH):
   a) 12.5 – 22.5 cm
   b) 22.6 – 32.5 cm

c) 32.6+ cm

The DBH is a guide and sample trees near the limit of a class will be considered in the adjacent class when there are difficulties achieving the class targets.

SAMPLE SIZE

The target is to sample 360 trees across the sample matrix (Table 1). The samples will be distributed using this matrix as a guide; however, the target number will not be achieved in some cells as the target site conditions are rare. The least important dimension of the matrix is geographic location. Thus, we will take advantage of encountering rare conditions, which will result in some degree of unbalance regarding geographic location.

Table 1. Sample matrix with target number of trees in each cell.

	1-2 yrs since attack			3-4 yrs since attack			5+ yrs since attack (01			
	Wet	Mesic	Dry	Wet	Mesic	Dry	Wet	Mesic	Dry	Total
Burns Lake & Area										
12.5 - 22.5 cm DBH	4	5	4	4	5	4	4	5	4	39
22.6 - 32.5 cm DBH	4	6	4	4	6	4	4	6	4	42
32.6 cm+ DBH	4	5	4	4	5	4	4	5	4	39
	12	16	12	12	16	12	12	16	12	120
Vanderhoof & Area										
12.5 - 22.5 cm DBH	4	5	4	4	5	4	4	5	4	39
22.6 - 32.5 cm DBH	4	6	4	4	6	4	4	6	4	42
32.6 cm+ DBH	4	5	4	4	5	4	4	5	4	39
	12	16	12	12	16	12	12	16	12	120
Quesnel & Area										
12.5 - 22.5 cm DBH	4	5	4	4	5	4	4	5	4	39
22.6 - 32.5 cm DBH	4	6	4	4	6	4	4	6	4	42
32.6 cm+ DBH	4	5	4	4	5	4	4	5	4	39
	12	16	12	12	16	12	12	16	12	120
Total	36	48	36	36	48	36	36	48	36	360

ATTRIBUTES OF INTEREST

The following variables will be noted, collected, or computed from the sample information.

Attribute	Variables
Site and General Stand Attributes	1. Geographic location and description 2. UTM coordinates 3. Slope, aspect, elevation, SMR, SNR 4. Area features affecting site conditions 5. Description of general extent and history of MPB attack 6. Digital photos
Stand Attributes	
1. General stand features:	Collected for trees >12.5 cm DBH from four prism plots (2 measure and 2 count plots). Plots are located 25 m at cardinal directions from the sample point center. 1. Stand density 2. Species composition 3. Basal area 4. Volume 5. Height 6. DBH
2. Small tree information:	Collected for trees >1.3 m in height and <12.5 cm DBH from one 3.99 m radius plot centered at each of the four prism plot locations. 1. Species 2. Live-dead code 3. MPB attack code 4. DBH (estimated)
3. Regeneration information	Collected for trees 0.3 – 1.3 m in height from one 2.50 m radius plot centered at each of the four prism plot locations. 1. Tally by species (live trees only)
4. MPB-Caused Coarse Woody Debris	Collected from an 11.28 m radius plot located at the sample point center. Measurements taken for coarse woody debris (including broken tops) caused by the MPB only. 1. Diameter 2. Length (height) 3. Tilt (degrees) 4. Decay class
Sample Tree Attributes	
1. Standing:	Collected from sample trees before falling. 1. Height 2. DBH 3. Estimated age of attack 4. Foliage color

Attribute	Variables
	5. Foliage proportion remaining 6. Proportion of bark intact (at breast height and for entire tree) 7. Loose bark at breast height 8. Severity of bird damage (woodpeckers, sapsuckers, flickers, etc.) 9. Crown class (pre-attack) 10. External check characteristics for first 2.5 m bolt 11. Digital photos
2. Fallen:	1. Tree length (reconstruct if broken)
Dendrochronology	Collected increment cores for 20 – 30 live Pl trees in each broad geographic area 1. Radial increment sequence (from lab measurements)
Disc Attributes	Take the following attributes for each stem analysis disc:
1. Checks:	1. Number of checks 2. Depth 3. Width 4. Azimuth 5. Pattern
2. Blue stain:	1. Average width of stain (by quadrant) 2. Degree (use Paprican's rating system) 3. Pattern
3. Decay:	1. Location 2. Type 3. Extent
4. Moisture content:	1. Sapwood 2. Heartwood 3. Pith
5. Bark:	1. Diameter outside bark 2. Bark thickness 3. Proportion of bark intact
6. Digital photos:	1. Digital photo of each disc

FIELD PROCEDURES

STEP 1 - SELECT SAMPLE AREA

As a guide, sample areas should be selected to include 5-10 sample trees. The areas are purposively selected across the widest geographic range possible to fill the sample matrix. Preference will be given to areas having trees with a wide range of time since death, DBH, and soil moisture conditions. Selecting sites will become more difficult as the sample size targets are met for the more common sample matrix cell conditions.

STEP 2 - SELECT & MEASURE SAMPLE TREES

Step 1 and 2 are done concurrently. Select the sample trees within about a 100 x 100 m area (1.0 ha). Sample trees should not be on edges (two tree lengths where the edge has been open for more than one year). Note sample tree in sample matrix.

The procedures are:

1. Mark sample trees:
   a) Mark breast height (BH) and stump height (0.3 m) with paint.
   b) Mark N and S with different colored paint (a line from stump to BH).
   c) Mark tree number (below BH) with paint.
2. Take digital picture of trees and stand.
3. Record external characteristics:
   a) Height.
   b) DBH.
   c) Crown class (pre-attack).
   d) Estimated time since attack.
   e) Loose bark at BH (Y/N).
   f) Proportion of bark intact at BH (%).
   g) Proportion of bark intact for entire tree (%).
   h) Severity of bird damage.
   i) Foliage conditions:
      i. Color.
      ii. Proportion of needles remaining.
   j) External check characteristics (first 2.5 m bolt):
      i. Width.
      ii. Length.
      iii. Depth
      iv. Spiral grain.

STEP 3 – DESCRIBE STAND & SITE CONDITIONS

Record for the sample area:

1. Site information:
   a) UTM coordinate (post-processed GPS data).
   b) Map plot features.
   c) Map site series group (wet, mesic, dry).

d) Slope, slope position, and aspect.

e) Elevation.

f) General weather conditions including temperature and precipitation.

2. Stand conditions:

   a) General stand structure (species, height, diameters).

   b) General MPB conditions (amount attacked, stage of attack).

STEP 4 – LOCATE & MEASURE SAMPLE PLOTS

1. Locate sample center point:

   a) Locate the sample center point in the geographic center of sample area. The idea is to distribute the four satellite sample point locations throughout the sample area to describe the general condition of the stand from where the sample trees are taken.

   b) Mark the sample point center with a wooden stake and label with plot number etc.

   c) There are no sample plots at the Integrated Plot Centre (IPC), but the coarse woody debris (CWD) plot originates from there.

2. Locate the four satellite plots:

   a) Locate plots at 25 m on cardinal directions from the sample center (Figure 12).

   b) Mark satellite plot centers with a wooden stake. Mark with ribbon and label with sample and plot number.

3. Install prism plots:

   a) Install one at each satellite plot location.

   b) Use the same prism on all four plots to gallow for an average of 5-6 trees (dead and live).

   c) Establish full measure plots at N and S and count plots at E and W.

   d) At measure plots, record for all live and dead trees:

      i) Tree number.

      ii) Species.

      iii) Tree class.

      iv) Height.

      v) DBH.

      vi) Path (conk, blind conk, scar, fork/crook, frost crack, mistletoe, rotten branch, dead or broken top).

      vii) Insect code.

      viii) Blowdown.

   e) At count plots, record:

      i) Tree number.

      ii) Species.

      iii) Tree class.

      iv) DBH.

      v) Insect code.

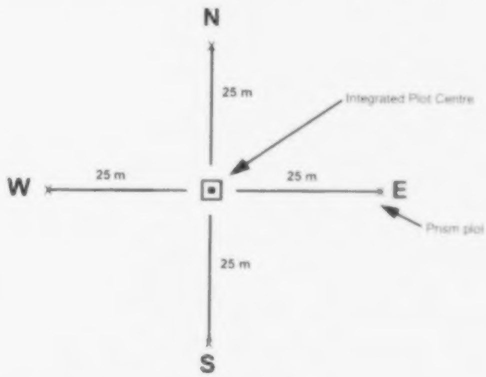


Figure 12. Cluster plot layout.

4. Install a 3.99 m radius small tree plot at each of the four satellite plot locations.

a) Small trees are >1.3 m in height and <12.5 cm DBH.

b) Tree measurements include:

i) Species.

ii) DBH (estimated).

iii) Tree class.

iv) MPB attack code.

5. Install a 2.5 m radius regeneration plot at each of the four satellite plot locations.

a) Regeneration in live trees from 0.3 - 1.3 m in height.

b) If estimated >200 live trees in plot, split plot and sample ½ or ¼ of plot. Flip a coin to select portion measured.

c) Tally live trees by species.

STEP 5 – SELECT & MEASURE RING SEQUENCE TREES

1. Select 20 - 25 live Pl trees from each general geographic area.
2. Select trees from sensitive sites (rocky outcrops, ridge tops).
3. Select dominant and co-dominant trees if possible.

a) Mark trees with flagging tape.

b) Extract one increment core from each tree near breast height (1.3 m).

c) Take core parallel to the slope (if slope exists).

d) Move location up or down if at a branch whorl.

e) Cores must be perfectly clean and even.

f) Core does not need to contain the pith but should contain at least 50 years of growth.

g) Label core and store in a labeled straw. Store straws in refrigerator and send to the J.S. Thrower and Associates' Kamloops office as soon as possible.

STEP 6 – MEASURE MPB-CAUSED COARSE WOODY DEBRIS

1. Establish an 11.28 m radius plot at the IPC.
2. Measure fallen or leaning MPB-killed Pl trees. If a tree has fallen out of the plot, it is measured if the point of germination is in the plot. Broken tops should also be measured.
3. Record for each piece >7.5 cm DBH:

a) DBH (cm).

b) Length (m).

c) Tilt (degrees).

d) Decay class.

STEP 7 – FALL & MEASURE SAMPLE TREES

1. Fall Tree:

a) Fall below 0.3 m mark if possible (leave 0.3 m intact to cut disc).

b) Fall tree to not interfere with other sample trees.

2. Buck limbs to expose bark condition and checks and allow rolling of logs.
3. Extend N- or S-painted line along length of the tree.
4. Measure tree height.

a) Record height from ground to tip.
b) Reconstruct broken tops to get full tree height.

5. Mark sectioning heights along stem:
   a) Paint a mark and the section height at 2.5 m intervals (from stump height).
   b) Move section point to avoid branch whorls or deformities.

STEP 8 - CUT SAMPLE DISCS

1. Cut discs at the marked section points.
2. Ensure a N or S mark is painted on each disc.
3. Cut discs 5-6 cm thick.
4. Mark each disc on the upper side with a N arrow, tree number, and height of the disc.
5. Mark end of each check on disc face.
6. Ensure discs are protected from weather (rain and sun) until measurements are taken.

STEP 9 - DISC MEASUREMENTS

These measurements should be taken as soon as possible after the discs are cut. Preferably, the measurements will be taken in the field or the same day at night in the lab.

1. Measure and record moisture content (MC) for each disc > 20 cm in diameter (nearest 1.0%):
   a) Mark quadrants on face of each disc.
   b) Record MC:
      i) Along each cardinal direction in:
         (1) Middle of the sapwood.
         (2) Outer heartwood.
         (3) Inner heartwood.
      ii) At pith.
   c) For discs <20 cm in diameter, record only sapwood and pith MC.
2. Measure and record:
   a) Diameter (cm) outside bark using steel tape. Reconstruct bark if fallen off.
   b) Average bark thickness (cm).
   c) Proportion (%) of bark intact.
3. If lab measurements and digital photographs can be completed in the field:
   a) Store BH discs in a burlap sack to count rings in the lab.
   b) Leave fully measured discs at site.
   c) Label each sack with sample area and tree numbers.
   d) Store BH discs in a cool and shady place.
4. If not possible to complete lab measurements in field:
   a) Store discs in a burlap sack and in a cool and shady place.
   b) Label sacks with site and tree numbers.
   c) Place in cold storage immediately if lab measurements cannot be done on the same day.

LAB MEASUREMENTS

All or as many of the lab measurements will be collected as soon as possible in the field. If it is not possible to collect all measurements in the field during destructive sampling, remaining measurements will be collected at night on the day of sampling. If lab measurements cannot be collected on the same day as sampling, the discs will be placed in cold storage until they can be measured.

The procedure to take detailed measurements on each disc in the lab is:

1. Label disc:
   a) Mark the four cardinal directions (if not done in the field). Make sure tree number and disc height are legible and visible on side where photo will be taken.
   b) Take high-resolution digital photo (use copy stand with scale).
2. Measure on each disc:
   a) Blue stain:
      i) Average width of stain in each quadrant.
      ii) Pattern of stain.
      iii) Degree of stain (use PAPRICAN rating scale).
   b) Checks (start at 360° and proceed clockwise):
      i) Azimuth
      ii) Depth (average of a straight line from cambium).
      iii) Width (at surface of cambium).
      iv) Pattern (straight, dog-legged,etc.).
   c) Decay (use NVAF procedures):
      i) Location.
      ii) Average width.
      iii) Type.

SCHEDULE

Overview

The goal is to start sampling May 15, 2006 in Quesnel if weather permits. The first shift will focus on crew training, familiarization with the project, and refining sampling efficiency. Sampling will proceed to Vanderhoof and finally to Burns Lake.

Prior to starting in the field, arrangements will be made for lab analysis space and cold storage in each area. Space will be arranged at motels or in warehouses at each location. Tentative dates will be arranged with local contacts in each area for reconnaissance of candidate sample sites. Field supplies for the entire project will be organized at the start of sampling and supplies will be monitored throughout the project.

Completed plot cards and digital images will be regularly copied, backed-up, and stored. Breast height discs will be stored in cold storage during each shift and transported to the Kamloops office for ring counting. Discs not measured in the field or at the end of each day will be placed in cold storage and transported to the Kamloops lab for measurement or additional cold storage.

Phase 1 – Preparation

1. Obtain Free-Use Permits for each geographic area from FrontCounter BC (Kamloops).
2. Produce GIS maps for target sampling areas with age of MPB attack.
3. Produce plot cards on waterproof paper.
4. Call local contacts to:
   a) Explain project.
   b) Arrange for a local person to accompany field crew on first day in area to locate candidate sample areas to meet the sample matrix.
   c) Tentatively arrange a date for reconnaissance in each area.
   d) Contact the Land Information Management Officer in each forest district for information on MPB attack dates and spread.
5. Prepare field equipment:
   a) Flagging.
   b) Stakes.
   c) Paint (two colors).
   d) Burlap sacks.
   e) Moisture meter.
   f) Digital camera.
   g) Field laptop.

Phase 2 – Field Sampling

1. Start field sampling May 15, 2006 or as soon as weather permits.
2. Field sampling to progress as:
   a) Quesnel (~38 days).
   b) Vanderhoof (~35 days).
   c) Burns Lake (~35 days).

3. The initial sample schedule is:

Location	Start Date	End Date	Approximate Field Days
Quesnel area	Middle of May	End of June	38
Vanderhoof area	Beginning of July	Middle of August	35
Burns Lake area	Middle of August	End of September	35

Phase 3 – Data Management and Reporting

1. Plot cards will be stored in a secure plot file at the end of each day.
2. Plot cards will be photocopied throughout the shift. Prior to leaving an area at the end of each shift, copies for all cards and data collected during the shift will be stored with local contacts for safe keeping.
3. Digital images will be uploaded to a laptop upon returning from the field each day.
   a) Stand and tree image files will be named with:
      i) Project number.
      ii) Site descriptor.
      iii) Site number.
      iv) Tree number.
   b) Disc image files will be named with:
      i) Project number.
      ii) Site number.
      iii) Tree number.
      iv) Disc height.
4. Digital files will be backed-up daily and at the end of each field shift.
5. All BH discs will be kept in cold storage during each shift. At the end of the shift, the discs will be transported to our Kamloops office for lab age analysis.
6. Any discs not measured will be transported to Kamloops for cold storage until they can be measured.
7. Dendrochronology analysis will start after the first field shift. Analysis results will be provided to the field crew to confirm and improve field calls of MPB attack and year of death.

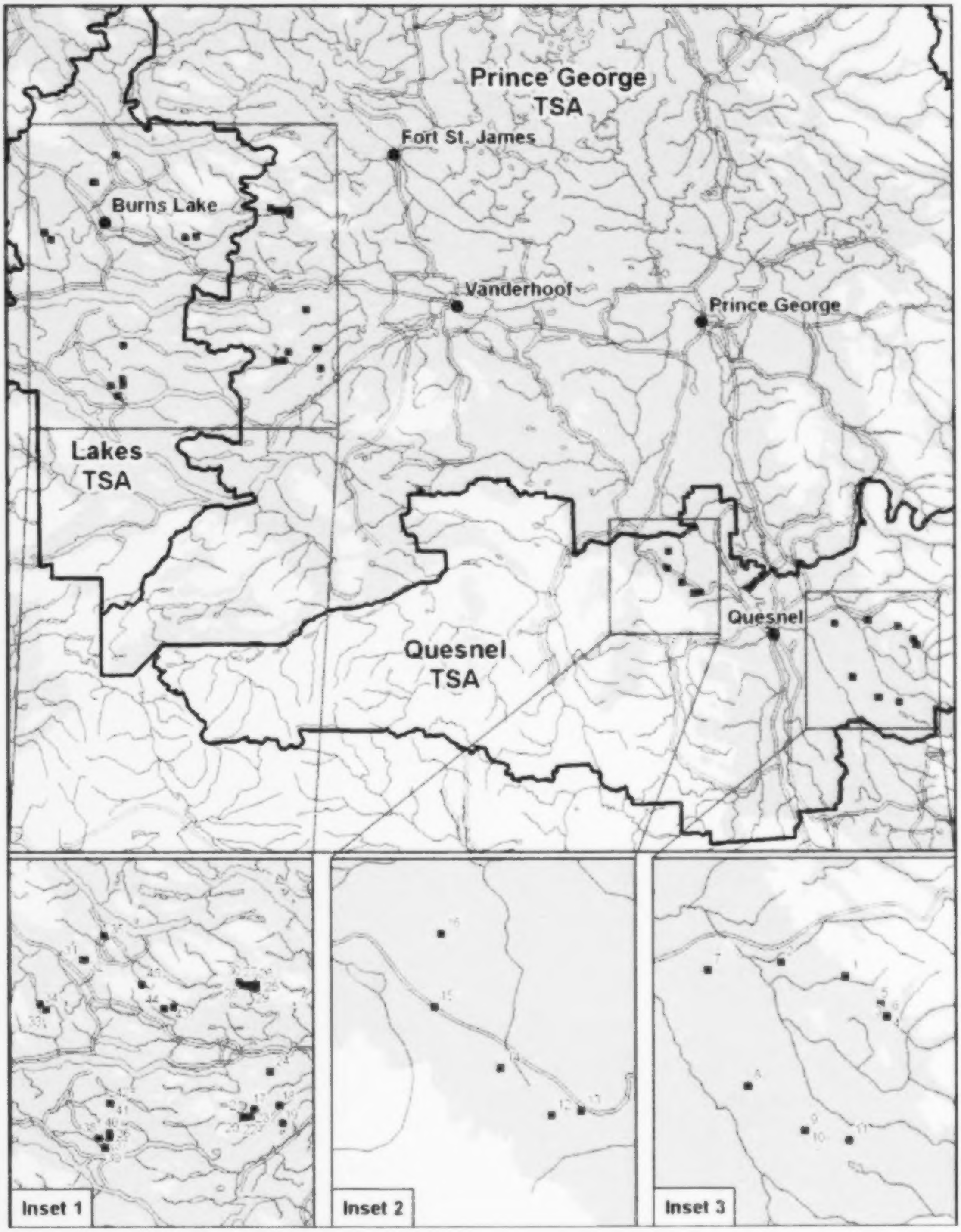
APPENDIX 2 – CHANGES FROM THE MARCH 2006 WORK PLAN

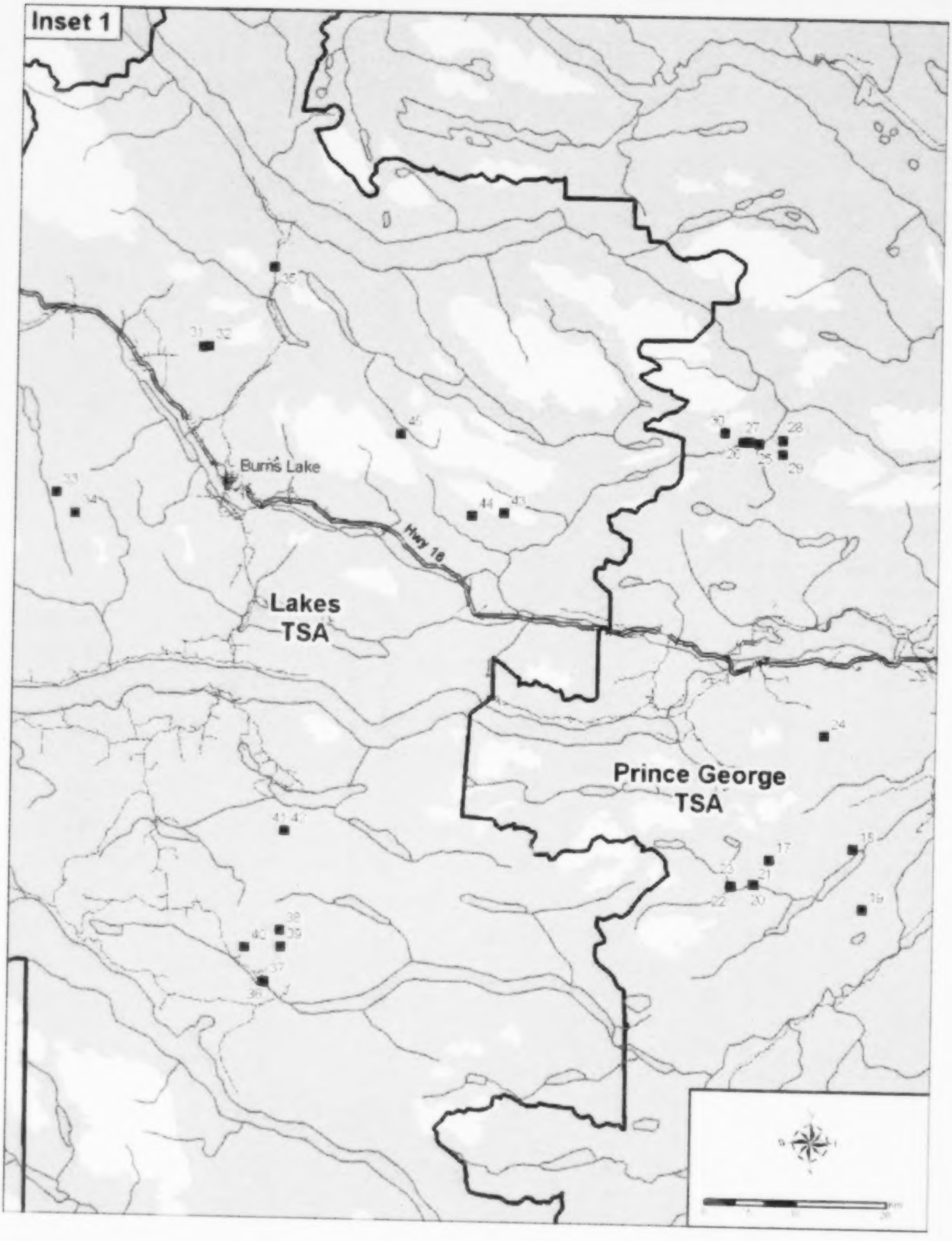
This appendix summarizes the changes from the sample and work plan submitted to the CFS on March 23, 2006.

Section	Original Sample & Work Plan	Change
1 Sample Design		
1.1 Overview		None
		None
1.3 Sample Unit		None.
1.4 Sample Matrix		None
1.5 Sample Size	- samples to be distributed as best as possible across the matrix	- geographic matrix targets not achieved but overall matrix targets mostly achieved
1.6 Attributes of Interest	- 20 - 30 dendrochronology samples collected for each geographic area	- no samples collected around Burns Lake
2 Field Procedures		
2.1 Step 1 - Select Sample Area	- as a guide, sample areas should be selected to include 5-10 sample trees	- most site have 5-10 sample trees with a range of 4-14
	- preference given to areas having trees with a wide range of time since death, DBH, and soil moisture	sites selected in this manner but with only one soil moisture condition
2.2 Step 2 - Select and Measure Sample Trees	- mark tree number below BH	- tree number painted above BH due to bark stripping for the MOFR project
2.3 Step 3 - Describe Stand & Site Conditions	- site information to include slope, slope position, and aspect	- attributes for each tree were collected instead of for the site in general
2.4 Step 4 - Locate & Measure Sample Plots		None
2.5 Step 5 - Select & Measure Ring Sequence Trees	- as noted in 1.6 above	- as noted in 1.6 above
2.6 Step 6 - Measure MPB Caused Coarse Woody Debris		None
2.7 Step 7 - Fall & Measure Sample Trees		None
2.8 Step 8 - Cut Sample Discs		None
2.9 Step 9 - Disc Measurements	a) that MC will be measured for each disc >20 cm in diameter i) along each cardinal direction, in:	

Section	Original Sample & Work Plan	Change
	1. Middle of the sapwood. 2. Outer heartwood. 3. Inner heartwood. ii) at pith. b) that MC will be measured for discs < 20 cm in diameter only in the sapwood and at pith.	MC measured for *all* discs: i) along each cardinal direction, in: 1. Middle of the sapwood. 2. Middle of the heartwood. ii) at pith.
3 Lab Measurements		
	- as many of lab measurements to be collected in the field	- *all* lab measurements collected in the field
	- measure blue stain using a Paprican rating scale	- did not have a rating scale from Paprican, but results from Paprican's more detailed measurements on a small sample of the discs showed a strong correlation with our ratings
	- average width of decay to be measured	- measured extent of decay as an area (cm^2) as this was the most consistent manner to record the size
4 Schedule		
4.1 Overview	- field sampling to start on May 15, 2006	- field sampling started on June 04, 2006
4.2 Phase 1 - Preparation	- contact the Land Information Management Officer in each forest district for information on MPB attack dates and spread.	- excellent information in all areas was received from local industry partners and thus MOFR assistance was not required
4.3 Phase 2 - Field Sampling	- as noted in 4.1 above	- as noted in 4.1 above
4.4 Phase 3 - Data Management and Reporting	- copies for all cards and data collected will be stored with local contacts for safe keeping at the end of each shift	- at the end of each shift, a copy was sent to Kamloops and the originals to Vancouver
	- as noted in 1.6 above	- as noted in 1.6 above

APPENDIX 3 – OVERVIEW MAPS OF SAMPLE SITE LOCATIONS

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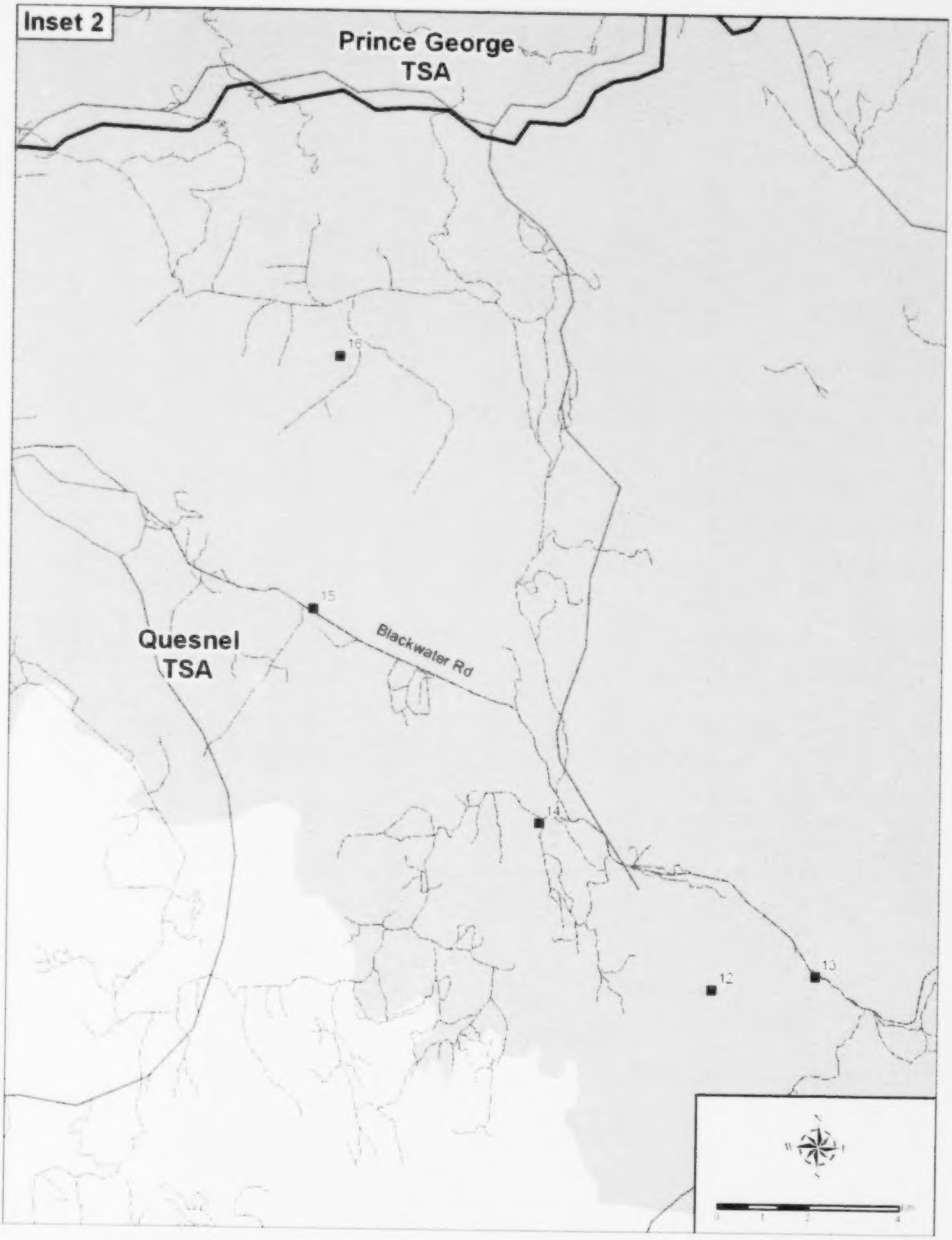
Burns Lake
Hwy 16
Lakes
TSA
Prince George
TSA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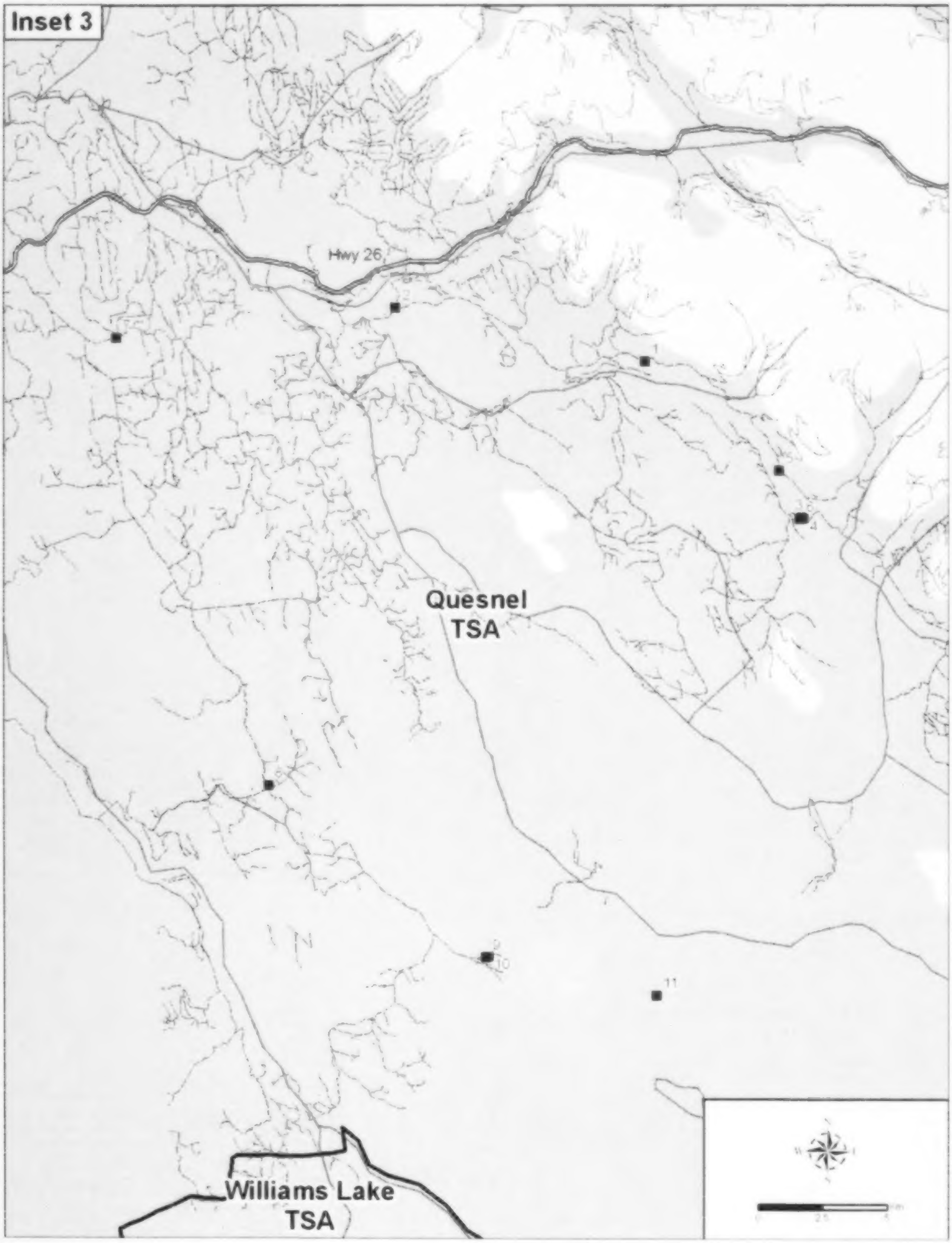
Prince George
TSA
16
15
Quesnel
TSA
Blackwater Rd
14
12
13


Inset 3
Hwy 26
Quesnel
TSA
Williams Lake
TSA

APPENDIX 4 – LIST OF SAMPLE SITES

Site	Trees	UTM Zone	UTM Northing	UTM Easting	Elevation (m)	BGC Unit	Site Series
	Quesnel Area						
1	1 - 5	10	5871589	573955	1070	SBSwk1	07
2	6 - 13	10	5874102	564276	934	SBSwk1	01
3	14 - 19	10	5865288	579804	1065	SBSwk1	06
4	20 - 25	10	5865232	579871	1060	SBSwk1	06
5	26 - 31	10	5867149	579018	1062	SBSwk1	01
6	32 - 37	10	5865223	579738	1064	SBSwk1	01
7	38 - 43	10	5873387	553359	956	SBSmw	01
8	44 - 49	10	5855720	558520	986	SBSmw	01
9	50 - 55	10	5848665	566735	1029	SBSmw	06
10	56 - 61	10	5848675	566814	1028	SBSmw	06
11	62 - 67	10	5846895	573342	1019	SBSmw	07
12	68 - 75, 105 - 110	10	5885257	507739	954	SBSdw1	04
13	76 - 86	10	5885481	510020	909	SBSdw1	01
14	87 - 95	10	5889038	504045	848	SBSdw2	03
15	96 - 104	10	5893900	499264	849	SBSdw2	01
16	111 - 120	10	5899403	500027	841	SBSdw2	01
	Vanderhoof Area						
17	121 - 130	10	5969540	379272	1131	SBSmc2	01
18	131 - 139	10	5970514	388614	842	SBSdk	01
19	140 - 149	10	5963819	389510	823	SBSdk	06
20	150 - 156	10	5966870	377492	917	SBSdk	01
21	157 - 162	10	5966839	377449	919	SBSdk	01
22	163 - 171	10	5966760	375038	957	SBSdk	06
23	172 - 176	10	5966724	374893	972	SBSdk	07
24	177 - 182	10	5983120	385716	816	SBSdk	01
25	183 - 192	10	6015486	379352	899	SBSdk	05
26	193 - 202	10	6015722	378308	879	SBSdk	03
27	203 - 212	10	6015693	377578	893	SBSdk	01
28	213 - 221	10	6015797	382000	933	SBSmc2	01
29	222 - 230	10	6014255	381937	988	SBSdk	01
30	231 - 240	10	6016804	375646	1080	SBSmc2	05
	Burns Lake Area						
31	241 - 249	10	6027704	318004	1017	SBSmc2	04
32	250 - 259	10	6027704	318545	1047	SBSmc2	01
33	260 - 269	9	6011799	692413	941	SBSdk	05
34	270 - 273	9	6009611	694616	1084	SBSmc2	01
35	274 - 282	10	6036255	326007	929	SBSmc2	01
36	283 - 289	10	5957415	322781	899	SBSdk	03
37	290 - 295	10	5957423	322705	805	SBSdk	03
38	296 - 301	10	5963018	324642	1128	SBSmc2	04
39	302 - 310	10	5961200	324709	1110	SBSmc2	01
40	311 - 315	10	5961190	320764	909	SBSdk	06
41	316 - 325	10	5974006	325491	891	SBSdk	01
42	326 - 335	10	5974031	325531	891	SBSdk	01
43	336 – 340	10	6008518	350779	1135	SBSmc2	07
44	341 – 350	10	6008305	347239	1028	SBSmc2	04
45	351 – 360	10	6017549	339454	1084	SBSmc2	01

APPENDIX 5 – LIST OF SAMPLE TREES

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
Quesnel	**Area**					
1	1	2001	Grey	32.3	50.3	SBSwk1
1	2	2001	Grey	24.4	31.2	SBSwk1
1	3	2001	Grey	34.5	48.6	SBSwk1
1	4	2001	Grey	32.3	43.1	SBSwk1
1	5	2001	Grey	30.3	35.6	SBSwk1
2	6	2005	E. Red	25.3	24.3	SBSwk1
2	7	2001	Grey	26.1	27.0	SBSwk1
2	8	2005	E. Red	22.3	20.2	SBSwk1
2	9	2001	Grey	24.6	28.7	SBSwk1
2	10	2005	E. Red	22.0	25.2	SBSwk1
2	11	2005	E. Red	23.7	24.0	SBSwk1
2	12	2001	Grey	27.4	31.5	SBSwk1
2	13	2005	E. Red	25.2	26.2	SBSwk1
3	14	2001	Grey	26.8	29.0	SBSwk1
3	15	2003	L. Red	26.8	26.7	SBSwk1
3	16	2003	L. Red	25.4	28.9	SBSwk1
3	17	2003	L. Red	24.8	24.6	SBSwk1
3	18	2001	Grey	24.7	24.4	SBSwk1
3	19	2005	E. Red	24.3	26.1	SBSwk1
4	20	2005	E. Red	20.9	21.1	SBSwk1
4	21	2003	L. Red	22.9	23.0	SBSwk1
4	22	2003	L. Red	21.3	22.4	SBSwk1
4	23	2002	L. Red	24.5	21.7	SBSwk1
4	24	2005	E. Red	22.4	22.3	SBSwk1
4	25	2001	Grey	25.4	26.6	SBSwk1
5	26	2004	E. Red	27.9	38.5	SBSwk1
5	27	2003	L. Red	26.5	37.8	SBSwk1
5	28	2001	Grey	29.3	36.9	SBSwk1
5	29	2002	L. Red	25.8	33.6	SBSwk1
5	30	2001	Grey	28.8	33.5	SBSwk1
5	31	2005	E. Red	25.4	35.7	SBSwk1
6	32	2002	L. Red	23.8	23.2	SBSwk1
6	33	2003	L. Red	26.6	33.2	SBSwk1
6	34	2002	L. Red	25.8	32.0	SBSwk1
6	35	2003	L. Red	26.2	26.3	SBSwk1
6	36	2001	Grey	24.7	23.8	SBSwk1
6	37	2002	L. Red	25.5	23.2	SBSwk1
7	38	2005	E. Red	17.3	19.5	SBSmw
7	39	2004	E. Red	17.2	19.9	SBSmw
7	40	2005	E. Red	16.4	19.2	SBSmw
7	41	2005	E. Red	17.2	20.2	SBSmw
7	42	2004	E. Red	16.2	22.4	SBSmw
7	43	2005	E. Red	15.6	19.5	SBSmw
8	44	2001	Grey	25.5	31.9	SBSmw
8	45	2001	Grey	26.4	40.4	SBSmw
8	46	2000	Grey	25.1	36.0	SBSmw
8	47	2000	Grey	23.3	28.0	SBSmw

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
8	48	2000	Grey	29.2	42.8	SBSmw
8	49	2000	Grey	23.9	35.3	SBSmw
9	50	2000	Grey	20.5	20.4	SBSmw
9	51	2002	L. Red	23.7	21.5	SBSmw
9	52	2002	L. Red	23.1	20.8	SBSmw
9	53	2000	Grey	26.7	25.7	SBSmw
9	54	2000	Grey	28.2	28.8	SBSmw
9	55	2000	Grey	23.2	21.7	SBSmw
10	56	2002	L. Red	30.0	33.0	SBSmw
10	57	2003	L. Red	29.1	33.1	SBSmw
10	58	2003	L. Red	28.9	32.5	SBSmw
10	59	2000	Grey	25.5	19.1	SBSmw
10	60	2002	L. Red	28.2	40.4	SBSmw
10	61	2000	Grey	26.2	20.4	SBSmw
11	62	2004	E. Red	24.4	23.8	SBSmw
11	63	2004	E. Red	28.8	37.3	SBSmw
11	64	2004	E. Red	25.4	25.1	SBSmw
11	65	2004	E. Red	23.4	27.7	SBSmw
11	66	2004	E. Red	23.9	36.5	SBSmw
11	67	2004	E. Red	21.2	20.6	SBSmw
12	68	2001	Grey	22.3	26.8	SBSdw1
12	69	2001	Grey	23.1	27.7	SBSdw1
12	70	2001	Grey	25.2	27.2	SBSdw1
12	71	2001	Grey	28.9	39.9	SBSdw1
12	72	2004	E. Red	21.4	18.9	SBSdw1
12	73	2001	Grey	22.6	22.1	SBSdw1
12	74	2004	E. Red	18.4	16.8	SBSdw1
12	75	2001	Grey	27.6	29.5	SBSdw1
13	76	2002	L. Red	23.2	20.4	SBSdw1
13	77	2003	L. Red	23.2	23.0	SBSdw1
13	78	2001	Grey	23.9	25.9	SBSdw1
13	79	2004	E. Red	19.6	17.6	SBSdw1
13	80	2001	Grey	22.6	21.6	SBSdw1
13	81	2001	Grey	22.5	22.7	SBSdw1
13	82	2003	L. Red	22.5	22.4	SBSdw1
13	83	2000	Grey	23.7	27.2	SBSdw1
13	84	2001	Grey	22.8	22.7	SBSdw1
13	85	2002	L. Red	22.1	21.3	SBSdw1
13	86	2001	Grey	23.5	22.9	SBSdw1
14	87	2004	E. Red	20.8	17.3	SBSdw2
14	88	2001	Grey	19.8	20.0	SBSdw2
14	89	2003	L. Red	18.2	18.2	SBSdw2
14	90	2003	L. Red	18.2	17.5	SBSdw2
14	91	2001	Grey	19.3	19.2	SBSdw2
14	92	2003	L. Red	19.9	19.0	SBSdw2
14	93	2002	L. Red	18.8	17.0	SBSdw2
14	94	2004	E. Red	18.1	16.3	SBSdw2
14	95	2001	Grey	18.8	18.4	SBSdw2
15	96	2000	Grey	29.6	33.5	SBSdw2
15	97	2001	Grey	26.1	34.4	SBSdw2
15	98	2001	Grey	26.4	32.1	SBSdw2

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
15	99	2003	L. Red	23.4	23.2	SBSdw2
15	100	2002	L. Red	24.8	25.0	SBSdw2
15	101	2004	E. Red	25.5	24.0	SBSdw2
15	102	2002	L. Red	22.8	23.3	SBSdw2
15	103	2004	E. Red	25.9	24.7	SBSdw2
15	104	2004	E. Red	25.3	23.4	SBSdw2
12	105	2004	E. Red	25.0	27.4	SBSdw1
12	106	2004	E. Red	24.8	27.5	SBSdw1
12	107	2004	E. Red	23.8	24.1	SBSdw1
12	108	2004	E. Red	23.7	30.0	SBSdw1
12	109	2004	E. Red	24.3	24.2	SBSdw1
12	110	2004	E. Red	23.3	24.2	SBSdw1
16	111	2002	L. Red	24.5	25.6	SBSdw2
16	112	2002	L. Red	23.9	24.4	SBSdw2
16	113	2001	Grey	23.9	25.5	SBSdw2
16	114	2001	Grey	23.9	34.4	SBSdw2
16	115	2001	Grey	24.7	32.4	SBSdw2
16	116	2001	Grey	25.2	27.7	SBSdw2
16	117	2003	L. Red	24.9	26.9	SBSdw2
16	118	2001	Grey	23.9	27.4	SBSdw2
16	119	2001	Grey	21.5	25.0	SBSdw2
16	120	2001	Grey	24.4	30.2	SBSdw2
Vanderhoof	**Area**					
17	121	2001	Grey	25.2	33.4	SBSmc2
17	122	2001	Grey	21.9	18.9	SBSmc2
17	123	2003	L. Red	21.3	16.6	SBSmc2
17	124	2001	Grey	21.1	21.1	SBSmc2
17	125	2001	Grey	21.6	20.4	SBSmc2
17	126	2002	L. Red	26.0	31.8	SBSmc2
17	127	2003	L. Red	25.7	37.0	SBSmc2
17	128	2001	Grey	24.9	33.0	SBSmc2
17	129	2001	Grey	23.9	30.0	SBSmc2
17	130	2000	Grey	21.5	16.8	SBSmc2
18	131	2001	Grey	20.9	19.1	SBSdk
18	132	2001	Grey	23.0	19.4	SBSdk
18	133	2001	Grey	23.7	17.7	SBSdk
18	134	2003	L. Red	21.5	19.1	SBSdk
18	135	2003	L. Red	22.5	19.4	SBSdk
18	136	2003	L. Red	21.5	21.3	SBSdk
18	137	2003	L. Red	21.8	20.7	SBSdk
18	138	2001	Grey	23.1	20.1	SBSdk
18	139	2001	Grey	20.4	17.3	SBSdk
19	140	2000	Grey	28.7	33.4	SBSdk
19	141	2000	Grey	26.3	27.1	SBSdk
19	142	2000	Grey	27.5	31.3	SBSdk
19	143	2000	Grey	29.7	33.1	SBSdk
19	144	2003	L. Red	23.6	17.3	SBSdk
19	145	2003	L. Red	24.4	19.9	SBSdk
19	146	1999	Grey	24.7	28.3	SBSdk
19	147	2000	Grey	26.0	37.3	SBSdk
19	148	2000	Grey	30.3	41.6	SBSdk

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
19	149	2003	L. Red	26.3	24.5	SBSdk
20	150	2000	Grey	24.2	33.3	SBSdk
20	151	2000	Grey	22.4	36.8	SBSdk
20	152	2000	Grey	21.6	31.5	SBSdk
20	153	1999	Grey	21.1	19.4	SBSdk
20	154	2000	Grey	22.5	27.6	SBSdk
20	155	1999	Grey	19.3	23.8	SBSdk
20	156	2000	Grey	20.9	21.7	SBSdk
21	157	2000	Grey	23.5	33.4	SBSdk
21	158	2001	Grey	21.1	19.1	SBSdk
21	159	2002	L. Red	21.8	19.8	SBSdk
21	160	2002	L. Red	18.3	20.9	SBSdk
21	161	2002	L. Red	19.4	20.4	SBSdk
21	162	2000	Grey	19.3	18.5	SBSdk
22	163	2002	L. Red	24.7	20.9	SBSdk
22	164	2001	Grey	25.2	16.9	SBSdk
22	165	2004	E. Red	22.4	17.3	SBSdk
22	166	2003	L. Red	24.3	19.0	SBSdk
22	167	2001	Grey	26.5	20.2	SBSdk
22	168	2001	Grey	23.3	16.3	SBSdk
22	169	2003	L. Red	27.9	31.5	SBSdk
22	170	2001	Grey	24.4	18.3	SBSdk
22	171	2003	L. Red	29.6	31.7	SBSdk
23	172	2002	L. Red	30.3	34.4	SBSdk
23	173	2003	L. Red	24.0	25.6	SBSdk
23	174	2002	L. Red	23.9	37.3	SBSdk
23	175	2002	L. Red	23.5	29.5	SBSdk
23	176	2002	L. Red	25.1	32.1	SBSdk
24	177	2002	L. Red	22.6	27.0	SBSdk
24	178	2001	Grey	24.0	36.1	SBSdk
24	179	2002	L. Red	22.5	24.7	SBSdk
24	180	2002	L. Red	25.4	32.6	SBSdk
24	181	2002	L. Red	27.3	34.0	SBSdk
24	182	2002	L. Red	26.3	29.1	SBSdk
25	183	2002	L. Red	24.5	33.1	SBSdk
25	184	2002	L. Red	26.5	37.4	SBSdk
25	185	2005	E. Red	23.3	33.1	SBSdk
25	186	2003	L. Red	21.5	25.8	SBSdk
25	187	2005	E. Red	20.3	21.1	SBSdk
25	188	2005	E. Red	18.5	16.3	SBSdk
25	189	2003	L. Red	19.7	17.1	SBSdk
25	190	2005	E. Red	21.4	20.2	SBSdk
25	191	2005	E. Red	20.3	19.9	SBSdk
25	192	2004	E. Red	22.6	29.2	SBSdk
26	193	2004	E. Red	25.9	30.4	SBSdk
26	194	2002	L. Red	25.7	35.7	SBSdk
26	195	2001	Grey	26.7	33.5	SBSdk
26	196	2002	L. Red	27.4	34.0	SBSdk
26	197	2002	L. Red	24.9	34.2	SBSdk
26	198	2004	E. Red	23.0	33.6	SBSdk
26	199	2005	E. Red	26.6	34.0	SBSdk

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
26	200	2003	L. Red	23.7	30.9	SBSdk
26	201	2001	Grey	25.8	36.8	SBSdk
26	202	2005	E. Red	25.0	34.5	SBSdk
27	203	2004	E. Red	28.3	35.6	SBSdk
27	204	2004	E. Red	24.0	27.6	SBSdk
27	205	2005	E. Red	24.0	26.0	SBSdk
27	206	2004	E. Red	22.7	22.6	SBSdk
27	207	2004	E. Red	25.1	24.0	SBSdk
27	208	2004	E. Red	26.3	39.6	SBSdk
27	209	2003	L. Red	22.9	26.6	SBSdk
27	210	2004	E. Red	28.6	37.2	SBSdk
27	211	2003	L. Red	32.2	33.8	SBSdk
27	212	2004	E. Red	32.6	37.6	SBSdk
28	213	2003	L. Red	25.2	39.3	SBSmc2
28	214	2004	E. Red	25.4	41.0	SBSmc2
28	215	2001	Grey	26.8	32.2	SBSmc2
28	216	2000	Grey	21.5	32.9	SBSmc2
28	217	2003	L. Red	26.7	39.0	SBSmc2
28	218	2003	L. Red	23.2	26.7	SBSmc2
28	219	2004	E. Red	26.2	37.8	SBSmc2
28	220	2003	L. Red	23.0	26.4	SBSmc2
28	221	2003	L. Red	25.9	34.5	SBSmc2
29	222	2001	Grey	25.1	31.2	SBSdk
29	223	2005	E. Red	18.7	22.5	SBSdk
29	224	2005	E. Red	17.9	19.7	SBSdk
29	225	2005	E. Red	21.9	31.9	SBSdk
29	226	2005	E. Red	15.6	20.3	SBSdk
29	227	2005	E. Red	20.7	23.9	SBSdk
29	228	2005	E. Red	18.3	18.1	SBSdk
29	229	2005	E. Red	18.9	28.5	SBSdk
29	230	2005	E. Red	15.9	30.3	SBSdk
30	231	2005	E. Red	20.1	26.7	SBSmc2
30	232	2005	E. Red	19.5	22.4	SBSmc2
30	233	2005	E. Red	19.4	26.1	SBSmc2
30	234	2004	E. Red	25.2	34.9	SBSmc2
30	235	2005	E. Red	21.7	28.8	SBSmc2
30	236	2005	E. Red	20.2	33.0	SBSmc2
30	237	2005	E. Red	21.9	29.7	SBSmc2
30	238	2005	E. Red	26.9	35.4	SBSmc2
30	239	2005	E. Red	25.4	35.2	SBSmc2
30	240	2004	E. Red	23.4	34.1	SBSmc2
Burns Lake	**Area**					
31	241	2003	L. Red	25.5	34.9	SBSmc2
31	242	2003	L. Red	24.4	34.0	SBSmc2
31	243	2004	E. Red	22.8	31.5	SBSmc2
31	244	2004	E. Red	22.8	32.9	SBSmc2
31	245	2004	E. Red	26.3	32.7	SBSmc2
31	246	2004	E. Red	24.8	34.1	SBSmc2
31	247	2004	E. Red	23.9	25.4	SBSmc2
31	248	2004	E. Red	26.3	33.9	SBSmc2
31	249	2004	E. Red	24.7	33.3	SBSmc2

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
32	250	2004	E. Red	27.0	39.3	SBSmc2
32	251	2004	E. Red	24.6	32.8	SBSmc2
32	252	2004	E. Red	21.8	21.9	SBSmc2
32	253	2004	E. Red	22.8	24.6	SBSmc2
32	254	2004	E. Red	25.4	30.1	SBSmc2
32	255	2005	E. Red	23.2	25.5	SBSmc2
32	256	2003	L. Red	23.4	25.0	SBSmc2
32	257	2003	L. Red	25.4	38.1	SBSmc2
32	258	2004	E. Red	27.5	37.9	SBSmc2
32	259	2004	E. Red	26.1	33.7	SBSmc2
33	260	2004	E. Red	27.9	42.1	SBSdk
33	261	2003	L. Red	26.4	39.5	SBSdk
33	262	2005	E. Red	26.1	33.0	SBSdk
33	263	2003	L. Red	24.5	34.8	SBSdk
33	264	2005	E. Red	24.1	34.1	SBSdk
33	265	2005	E. Red	24.7	32.6	SBSdk
33	266	2003	L. Red	28.3	36.1	SBSdk
33	267	2005	E. Red	23.6	34.8	SBSdk
33	268	2005	E. Red	27.1	33.6	SBSdk
33	269	2003	L. Red	24.7	36.9	SBSdk
34	270	2003	L. Red	23.6	32.9	SBSmc2
34	271	2003	L. Red	22.5	33.4	SBSmc2
34	272	2005	E. Red	21.5	33.1	SBSmc2
34	273	2004	E. Red	23.9	34.4	SBSmc2
35	274	2003	L. Red	23.5	30.9	SBSmc2
35	275	2004	E. Red	27.4	35.8	SBSmc2
35	276	2004	E. Red	25.5	33.5	SBSmc2
35	277	2004	E. Red	23.9	27.4	SBSmc2
35	278	2005	E. Red	20.3	23.9	SBSmc2
35	279	2003	L. Red	22.9	26.3	SBSmc2
35	280	2003	L. Red	21.9	20.5	SBSmc2
35	281	2003	L. Red	22.3	29.4	SBSmc2
35	282	2004	E. Red	23.6	35.9	SBSmc2
36	283	2004	E. Red	21.8	23.3	SBSdk
36	284	1999	Grey	25.0	32.9	SBSdk
36	285	1999	Grey	25.1	36.8	SBSdk
36	286	1999	Grey	25.7	33.4	SBSdk
36	287	1999	Grey	23.6	37.9	SBSdk
36	288	2000	Grey	21.6	17.0	SBSdk
36	289	2000	Grey	21.2	17.1	SBSdk
37	290	2004	E. Red	19.3	15.4	SBSdk
37	291	2004	E. Red	20.6	15.9	SBSdk
37	292	2005	E. Red	19.0	17.7	SBSdk
37	293	2004	E. Red	19.3	17.4	SBSdk
37	294	2000	Grey	15.6	16.9	SBSdk
37	295	2000	Grey	20.1	20.0	SBSdk
38	296	2001	Grey	25.5	35.4	SBSmc2
38	297	2001	Grey	26.5	35.4	SBSmc2
38	298	2001	Grey	26.1	33.0	SBSmc2
38	299	2001	Grey	24.3	27.1	SBSmc2
38	300	2001	Grey	27.7	32.7	SBSmc2

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
38	301	2001	Grey	23.7	31.6	SBSmc2
39	302	2003	L. Red	19.4	20.1	SBSmc2
39	303	2003	L. Red	22.3	21.5	SBSmc2
39	304	2003	L. Red	23.1	21.1	SBSmc2
39	305	2003	L. Red	23.2	30.3	SBSmc2
39	306	2003	L. Red	23.8	25.8	SBSmc2
39	307	2003	L. Red	20.4	22.2	SBSmc2
39	308	2003	L. Red	20.0	21.9	SBSmc2
39	309	2003	L. Red	20.3	18.5	SBSmc2
39	310	2003	L. Red	19.8	22.8	SBSmc2
40	311	2001	Grey	25.6	31.0	SBSdk
40	312	2000	Grey	29.9	37.8	SBSdk
40	313	2000	Grey	22.0	33.7	SBSdk
40	314	2001	Grey	27.0	34.2	SBSdk
40	315	2001	Grey	27.4	38.7	SBSdk
41	316	2001	Grey	18.0	16.9	SBSdk
41	317	2002	L. Red	20.6	18.5	SBSdk
41	318	2002	L. Red	20.1	20.3	SBSdk
41	319	2000	Grey	19.5	18.6	SBSdk
41	320	2002	L. Red	21.8	20.2	SBSdk
41	321	2000	Grey	20.6	22.4	SBSdk
41	322	2000	Grey	20.7	19.8	SBSdk
41	323	2001	Grey	19.2	19.8	SBSdk
41	324	2002	L. Red	21.2	19.9	SBSdk
41	325	2002	L. Red	22.3	22.1	SBSdk
42	326	2000	Grey	20.5	23.1	SBSdk
42	327	2000	Grey	21.5	20.9	SBSdk
42	328	2000	Grey	20.5	22.4	SBSdk
42	329	2002	L. Red	22.9	21.1	SBSdk
42	330	2002	L. Red	20.4	17.7	SBSdk
42	331	2000	Grey	23.2	27.3	SBSdk
42	332	2000	Grey	20.2	20.5	SBSdk
42	333	2003	L. Red	22.8	22.3	SBSdk
42	334	2001	Grey	21.4	20.5	SBSdk
42	335	2002	L. Red	21.1	20.8	SBSdk
43	336	2003	L. Red	24.4	34.1	SBSmc2
43	337	2003	L. Red	26.4	34.3	SBSmc2
43	338	2003	L. Red	26.3	33.1	SBSmc2
43	339	2003	L. Red	23.6	33.2	SBSmc2
43	340	2003	L. Red	24.9	33.2	SBSmc2
44	341	2005	E. Red	23.6	24.7	SBSmc2
44	342	2005	E. Red	23.9	25.1	SBSmc2
44	343	2005	E. Red	19.5	20.3	SBSmc2
44	344	2005	E. Red	19.4	17.0	SBSmc2
44	345	2005	E. Red	22.5	23.1	SBSmc2
44	346	2005	E. Red	23.4	22.5	SBSmc2
44	347	2005	E. Red	23.1	21.0	SBSmc2
44	348	2005	E. Red	24.1	23.2	SBSmc2
44	349	2005	E. Red	19.8	20.6	SBSmc2
44	350	2005	E. Red	21.3	21.5	SBSmc2
45	351	2003	L. Red	23.2	29.4	SBSmc2

Site	Tree	Year of MPB Attack	Foliage Condition Class	Tree Length (m)	DBH (cm)	BGC Unit
45	352	2003	L. Red	22.2	26.7	SBSmc2
45	353	2003	L. Red	24.7	36.1	SBSmc2
45	354	2003	L. Red	26.2	37.1	SBSmc2
45	355	2003	L. Red	21.3	34.5	SBSmc2
45	356	2003	L. Red	21.5	25.8	SBSmc2
45	357	2005	E. Red	18.9	18.6	SBSmc2
45	358	2005	E. Red	19.1	21.1	SBSmc2
45	359	2003	L. Red	26.5	34.8	SBSmc2
45	360	2003	L. Red	19.5	33.7	SBSmc2

APPENDIX 6 – DATABASE STRUCTURE & TABLES

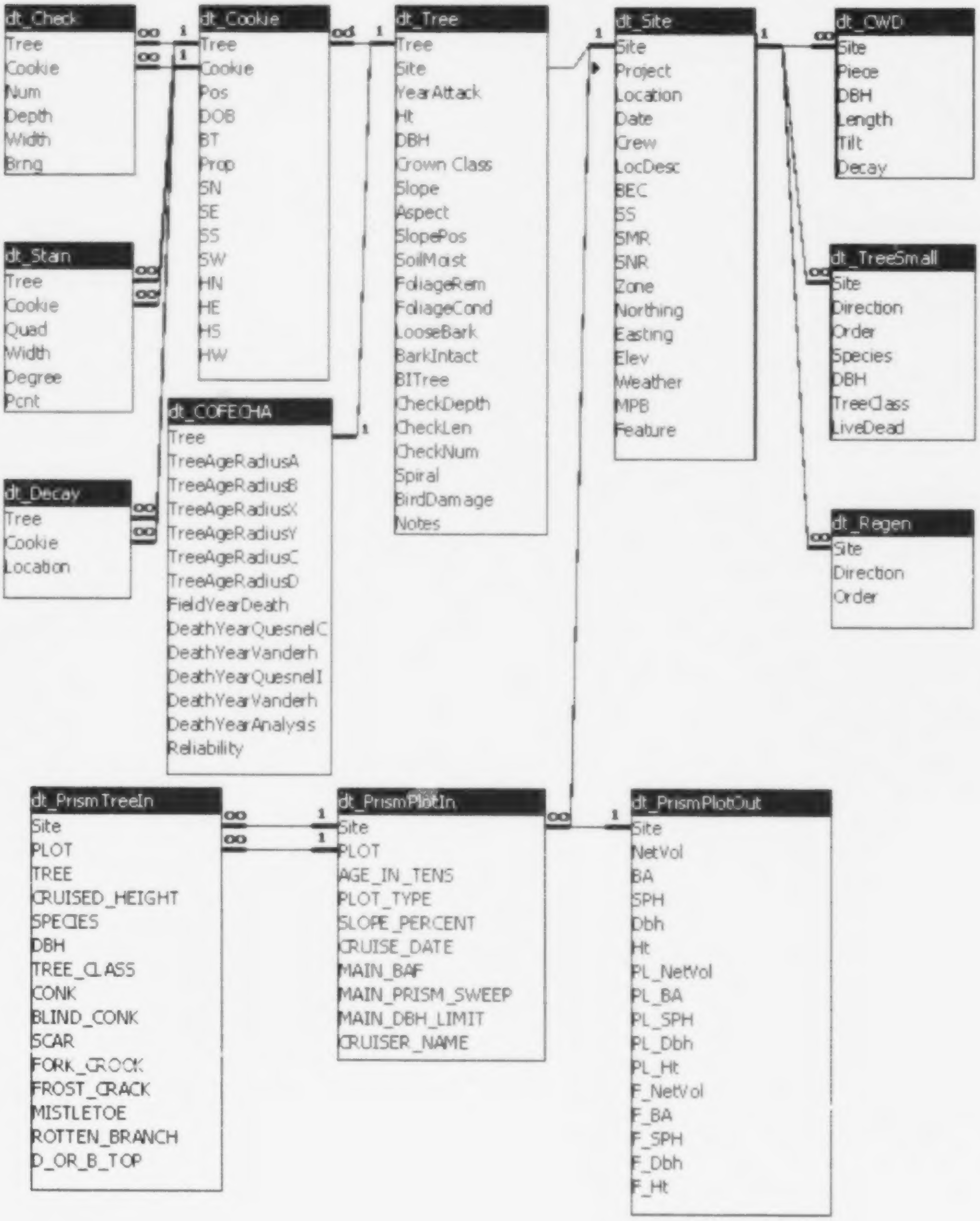


Table: dt_Check Contains data for the checks measured on each sample disc. Discs are referred to as cookies in this table.

Num	Field Name	Type	Size	Description
1	Tree	Integer		Tree number (1-360)
2	Cookie	Integer		Disc number, numbered up the tree from stump height (0.0m) = 1
3	Num	Integer		Check number, numbered clockwise from north; 9999 = no check
4	Depth	Single		Check depth (cm) from cambium; 9999 = no check
5	Width	Single		Check width (cm) at cambium; 9999 = no check
6	Brng	Integer		Bearing from pith (degrees); 9999 = no check
7	Pattern	Text	4	Pattern: (S)traight; (C)urved; (D)oglegged; S(P)lintered; #### = no check

Table: dt_Stain Contains data for blue stain attributes measured from the sample discs. Discs are referred to as cookies in this table.

Num	Field Name	Type	Size	Description
1	Tree	Integer		Tree number (1-360)
2	Cookie	Integer		Disc number, numbered up the tree from stump height (0.0m) = 1
3	Quad	Integer		Quadrant delineated on the disc face, clockwise from north: 1 (NE); 2(SE); 3(SW) or 4(NW)
4	Width	Single		Average width (cm) of stain measured from cambium towards pith in each quadrant; 9999 = no stain
5	Degree	Integer		Visual estimate of blue stain intensity in each quadrant: 1=Light; 2=Moderate; 3=Dark; 9999 = no stain
6	Pcnt	Integer		Visual estimate of blue stain percent in each quadrant (%); 9999 = no stain
7	Pattern	Text	4	Visual determination of blue stain pattern in each quadrant: (S)olid; (P)atchy; #### = no stain

Table: dt_Decay Contains data for decay attributes measured from the sample discs. Discs are referred to as cookies in this table.

Num	Field Name	Type	Size	Description
1	Tree	Integer		Tree number (1-360)
2	Cookie	Integer		Disc number, numbered up the tree from stump height (0.0m) = 1
3	Location	Text	4	Decay location in the disc: (S)apwood; (H)eartwood; (B)oth; #### = no decay
4	Type	Text	4	Decay type: (IS) Insipient Stain; (BC) Brown Cubical; (BR) Buttrot; (PP) Phellinus pini; (PR) Punky Rot; (SR) Saprot; (TD) Termite Damage; #### = no decay
5	Extent	Integer		Decay extent measured as an area on the disc face (cm2); 9999 = no decay

Table: dt_Cookie		Contains data on the height where the discs were cut and for moisture content attributes of the sample discs. The discs (cookies) were taken at 2.5 m intervals from stump height, and at BH and near the top where the stem reached 10 cm diameter inside bark. Discs are referred to as cookies in this table.		
Num	Field Name	Type	Size	Description
1	Tree	Integer		Tree number (1-360)
2	Cookie	Integer		Disc number, numbered up the tree from stump height (0.0m) = 1
3	Pos	Single		Actual position of disc which may differ from the 2.5m target log length (m)
4	DOB	Single		Diameter outside bark measured with a steel diameter tape (cm)
5	BT	Single		Average bark thickness for disc (cm)
6	Prop	Integer		Proportion of the bark intact as a percent of circumference and measured with a steel diameter tape (%)
7	SN	Integer		North axis sapwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
8	SE	Integer		East axis sapwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
9	SS	Integer		South axis sapwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
10	SW	Integer		West axis sapwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
11	HN	Integer		North axis heartwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
12	HE	Integer		East axis heartwood moisture percent measured with the Delmhorst J2000 metert; 6 = <7%, 41 = >40%
13	HS	Integer		South axis heartwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
14	HW	Integer		West axis heartwood moisture percent measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%
15	Pith	Integer		Pith moisture measured with the Delmhorst J2000 meter; 6 = <7%, 41 = >40%

Table: dt_Tree		Contains data for general descriptor attributes for each sample tree. These attributes were recorded prior to falling the tree. Attributes used in the sample matrix are in this table.		
Num	Field Name	Type	Size	Description
1	Tree	Integer		Tree number (1-360)
2	Site	Integer		Site number (1-45)
3	YearAttack	Integer		Field crew estimate of the year of MPB attack
4	Ht	Single		Total tree height (m) measured with a vertex
5	DBH	Single		Diameter at breast height (cm) measured with a steel diameter tape
6	Crown Class	Text	1	Crown class: (D)ominant; (C)odominant; (I)intermediate
7	Slope	Integer		Slope of the ground at the tree (%)
8	Aspect	Integer		Aspect of the area at the tree in degrees; 0 = no aspect
9	SlopePos	Text	2	Slope position of the area at the tree
10	SoilMoist	Text	1	Broad soil moisture estimate of the ground at the tree (W)et; (M)esic; (D)ry
11	FoliageRem	Integer		Visual estimate in the field of the foliage remaining (%)
12	FoliageCond	Text	1	Visual estimate in the field of the foliage condition: (E)arly red; (L)ate red; (G)rey
13	LooseBark	Text	1	Loose bark at breast height measured by pressing the bark: (Y)es; (N)o
14	BarkIntact	Integer		Percent of bark intact at breast height measured with a steel diameter tape (%)
15	BITree	Integer		Visual estimate in the field of the percent of bark intact for the entire tree (%)
16	CheckDepth	Single		Maximum depth (cm) of checking in first 2.5 m log from stump height measured on the standing tree; 9999 = no check visible
17	CheckLen	Single		Average length (m) of checking in first 2.5 m log from stump height measured on the standing tree; 9999 = no check visible
18	CheckNum	Single		Number of checks in first 2.5 m log from stump height measured on the standing tree; 9999 = no check visible
19	Spiral	Integer		Maximum spiral grain (%) in first 2.5 m log from stump height measured on the standing tree
20	BirdDamage	Text	1	Visual estimate in the field of the severity of bird damage for the entire tree: (N)one; (L)ow; (M)oderate; (H)igh
21	Notes	Text	255	General notes regarding the sample tree; #### = no notes
22	TreeLen	Single		Measured tree length (m) on the ground using a fiberglass tape

Table: dt_Site

Contains data for the attributes describing each site. These attributes were recorded prior to and while sampling each site.

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number (1-45)
2	Project	Text	7	JS Thrower internal project number
3	Location	Text	20	Geographic location (Quesnel, Vanderhoof, Burns Lake)
4	Date	Date/Time		Date the site was sampled (dd/mmm/year)
5	Crew	Text	20	Crew initials (JW=Jim Webb, BM=Bruce McMahon, CT=Carolyn Thorp, SC=Shawn Corrigan)
6	LocDesc	Text	50	General location description
7	BEC	Text	12	Biogeoclimatic unit (BEC zone, subzone and variant)
8	SS	Text	10	BEC Site Series
9	SMR	Text	12	BEC Soil Moisture Regime
10	SNR	Text	12	BEC Soil Nutrient Regime
11	Zone	Integer		UTM Zone at the Integrated Plot Center
12	Northing	Long		UTM Northing at the Integrated Plot Center
13	Easting	Long		UTM Easting at the Integrated Plot Center
14	Elev	Integer		Elevation (m) at the Integrated Plot Center
15	Weather	Text	100	General description of the weather at the time of sampling
16	MPB	Text	255	General extent and history of MPB attack in stand
17	Feature	Text	200	Area features affecting site conditions
18	Access	Memo		Access notes

Table: dt_CWD

Contains data for attributes describing Coarse Woody Debris (CWD) at each site. These attributes were recorded in an 11.28 m radius plot located at the Integrated Plot Centre (IPC) (centre of the plot cluster).

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number(1-45)
2	Piece	Integer		Coarse woody debris piece number measured in the 11.28m radius plot centered at the Integrated Plot Center; 9999 = no CWD
3	DBH	Single		Diameter at breast height (cm) measured with a steel diameter tape; 9999 = no CWD
4	Length	Single		Length (m) of coarse woody debris piece; 9999 = no CWD
5	Tilt	Integer		Tilt (degrees) measured on the coarse woody debris; 9999 = no CWD
6	Decay	Text	4	Decay class based on VRI standards (1-5); 9999 = no CWD
7	Notes	Text	100	General notes regarding the coarse woody debris; #### = no CWD

Table: dt_TreeSmall — Contains data for the small trees measured in four auxiliary plots in each cluster. These trees (>1.3m tall and <12.5cm DBH) were measured from 3.99 m radius plots.

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number (1-45)
2	Direction	Text	1	Plot location at cardinal direction from plot center: (N)orth; (E)ast; (S)outh; (W)est
3	Order	Long		Internal database auto-number based on data entry sequence
4	Species	Text	6	Species code (MOFR timber crusing standard); #### = no small tree
5	DBH	Single		Diameter at breast height (cm) measured with either a steel diameter tape or a 15cm steel scale; 9999 = no small tree
6	TreeClass	Text	1	Tree Class (D)ominant,(C)odominant, (I)ntermediate, (S)uppressed; # = no small tree
7	LiveDead	Text	1	Field classification of tree as (L)ive or (D)ead; # = no small tree
8	MPB	Text	2	MPB attack code; 0 = no beetle attack, 1 = green attack, 2 = red attack, 3 = grey attack

Table: dt_Regen — Contains data for regeneration trees measured in each of the four auxiliary plots. These trees (<1.3 m tall) were measured from 2.5 m radius plots.

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number (1-45)
2	Direction	Text	1	Plot location at cardinal direction from plot center: (N)orth; (E)ast; (S)outh; (W)est
3	Order	Long		Internal database auto-number based on data entry sequence
4	Species	Text	6	Species code (MOFR timber crusing standard); #### = no regeneration
5	Count	Integer		Count (number of regeneration trees); 9999 = no regeneration

Table: dt_PrismTreeIn

Contains data for trees ≥12.5 cm DBH in each of the four auxiliary plots. These data were collected using a variable radis (prism) plot according to MOFR timber cruising standards. The data were compiled in CruiseComp 2006.01 and exported to MS Access.

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number (1-45)
2	PLOT	Integer		Plot number (1=north; 2=east; 3=south; 4=west)
3	TREE	Integer		Unique tree number within the plot
4	CRUISED_HEIGHT	Double		Total tree height (m)
5	SPECIES	Text	2	Species code (MOFR timber cruising standard)
6	DBH	Double		Diameter at breast height measured with a steel diameter tape (cm)
7	TREE_CLASS	Integer		Tree class (1-9 based on MOFR timber cruising standard)
8	CONK	Integer		Pathological remark position code for conks (MOFR timber cruising standard)
9	BLIND_CONK	Integer		Pathological remark position code for blind conks (MOFR timber cruising standard)
10	SCAR	Integer		Pathological remark position code for scars (MOFR timber cruising standard)
11	FORK_CROOK	Integer		Pathological remark position code for fork and crooks (MOFR timber cruising standard)
12	FROST_CRACK	Integer		Pathological remark position code for frost cracks (MOFR timber cruising standard)
13	MISTLETOE	Integer		Pathological remark position code for mistletoe (MOFR timber cruising standard)
14	ROTTEN_BRANCH	Integer		Pathological remark position code for rotten branches (MOFR timber cruising standard)
15	D_OR_B_TOP	Integer		Pathological remark position code for dead or broken tops (MOFR timber cruising standard)
16	SPIRAL_GRAIN	Integer		Pathological remark position code for spiral grain (MOFR timber cruising standard)
17	INSECT	Text	1	Pathological remark position code for insect attack (MOFR timber cruising standard)
18	FIRE	Text	1	Pathological remark position code for fire damage (MOFR timber cruising standard)
19	BLOWDOWN	Text	1	Pathological remark position code for blowdown (MOFR timber cruising standard)

Table: dt_PrismPlotIn Contains header data related to the variable radius (prism) plots taken at each of the four auxiliary plot locations.

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number (1-45)
2	PLOT	Integer		Plot number (1=north, 2=east, 3=south, 4=west)
3	AGE_IN_TENS	Integer		Age class in decades (MOFR timber cruising standard)
4	PLOT_TYPE	Text	1	M - measure plot (all tree info recorded), C - enhanced count plot (only tree#, species recorded and diameter at breast height recorded)
5	SLOPE_PERCENT	Integer		Maximum slope of ground in a plot (0-150%)
6	CRUISE_DATE	Text	4	Year and month that plot was cruised
7	MAIN_BAF	Double		Prism plot basal area factor for main plot
8	MAIN_PRISM_SWEEP	Text	1	F-full sweep, H-half sweep, B-border plot sweep for main plot; all plots were full plots
9	MAIN_DBH_LIMIT	Double		Diameter at breast height limit for main plot (12.5cm) - only trees equal and greater than this limit are used with the main prism or main hectares
10	CRUISER_NAME	Text	32	Cruiser's name
11	MEMO	Text	250	General notes about the site

Table: dt_PrismPlotOut

Contains the compiled data for trees >12.5 cm DBH from the auxiliary plots. These data describe the general stand conditions at each sample site. These data were compiled in CruiseComp 2006.01 and exported to MS Access.

Num	Field Name	Type	Size	Description
1	Site	Integer		Site number (1-45)
2	NetVol	Single		Net volume (m3/ha) from the four prism plots at the site
3	BA	Single		Basal Area (m2/ha) from the four prism plots at the site
4	SPH	Single		Stems per hectare from the four prism plots at the site
5	Dbh	Single		Average Diameter at Breast Height (cm) from the four prism plots at the site
6	Ht	Single		Average Tree Height (m) from the four prism plots at the site
7	PL_NetVol	Single		Net Volume per hectare (m3/ha) for lodgepole pine from the four prism plots at the site
8	PL_BA	Single		Basal Area (m2/ha) for lodgepole pine from the four prism plots at the site
9	PL_SPH	Single		Stems per hectare for lodgepole pine from the four prism plots at the site
10	PL_Dbh	Single		Average Diameter at Breast Height (cm) for lodgepole pine from the four prism plots at the site
11	PL_Ht	Single		Average Tree Height (m) for lodgepole pine from the four prism plots at the site
12	F_NetVol	Single		Net Volume per hectare (m3/ha) for Douglas-fir from the four prism plots at the site
13	F_BA	Single		Basal Area (m2/ha) for Douglas-fir from the four prism plots at the site
14	F_SPH	Single		Stems per hectare for Douglas-fir from the four prism plots at the site
15	F_Dbh	Single		Average Diameter at Breast Height (cm) for Douglas-fir from the four prism plots at the site
16	F_Ht	Single		Average Tree Height (m) for Douglas-fir from the four prism plots at the site
17	S_NetVol	Single		Net Volume per hectare (m3/ha) for Spruce species from the four prism plots at the site
18	S_BA	Single		Basal Area (m2/ha) for Spruce species from the four prism plots at the site
19	S_SPH	Single		Stems per hectare for Spruce species from the four prism plots at the site
20	S_Dbh	Single		Average Diameter at Breast Height (cm) for Spruce species from the four prism plots at the site
21	S_Ht	Single		Average Tree Height (m) for Spruce species from the four prism plots at the site
22	BL_NetVol	Single		Net Volume per hectare (m3/ha) for Abies species from the four prism plots at the site
23	BL_BA	Single		Basal Area (m2/ha) for Abies species from the four prism plots at the site
24	BL_SPH	Single		Stems per hectare for Abies species from the four prism plots at the site
25	BL_Dbh	Single		Average Diameter at Breast Height (cm) for Abies species from the four prism plots at the site
26	BL_Ht	Single		Average Tree Height (m) for Abies species from the four prism plots at the site
27	AC_NetVol	Single		Net Volume per hectare (m3/ha) for Cottonwood from the four prism plots at the site
28	AC_BA	Single		Basal Area (m2/ha) for Cottonwood from the four prism plots at the site
29	AC_SPH	Single		Stems per hectare for Cottonwood from the four prism plots at the site
30	AC_Dbh	Single		Average Diameter at Breast Height (cm) for Cottonwood from the four prism plots at the site
31	AC_Ht	Single		Average Tree Height (m) for Cottonwood from the four prism plots at the site
32	AT_NetVol	Single		Net Volume per hectare (m3/ha) for Tembling Aspen from the four prism plots at the site

Table: dt_PrismPlotOut

Contains the compiled data for trees >12.5 cm DBH from the auxiliary plots. These data describe the general stand conditions at each sample site. These data were compiled in CruiseComp 2006.01 and exported to MS Access.

Num	Field Name	Type	Size	Description
33	AT_BA	Single		Basal Area (m2/ha) for Trembling Aspen from the four prism plots at the site
34	AT_SPH	Single		Stems per hectare for Trembling Aspen from the four prism plots at the site
35	AT_Dbh	Single		Average Diameter at Breast Height (cm) for Trembling Aspen from the four prism plots at the site
36	AT_Ht	Single		Average Tree Height (m) for Trembling Aspen from the four prism plots at the site

APPENDIX 7 – DATA FOR THE OVEN-DRY MOISTURE CONTENT COMPARISON

Piece	Wet Mass (g)	Field Moistures (%) Meter 1 (Delmhorst J2000 No. 26614)						Avg with ends	Avg without ends	Field Moistures (%) Meter 2 (Delmhorst J2000 No. 28678)						Avg with ends	Avg without ends	Oven-Dry Moisture	
		Side 1	Side 2	Side 3	Side 4	End 1	End 2			Side 1	Side 2	Side 3	Side 4	End 1	End 2			Dry Mass (g)	Moisture (%)
A	25.95	33.7	36.0	32.2	34.6	20.6	27.2	30.7	34.1	34.4	34.7	32.2	35.0	21.8	28.3	31.1	34.1	19.27	34.7
B	11.57	35.1	31.3	34.2	32.2	20.5	27.2	30.1	33.2	33.6	33.0	33.3	30.3	20.3	26.1	29.4	32.6	8.64	33.9
C	39.95	21.1	23.6	24.0	23.2	18.1	19.3	21.6	23.0	21.6	23.7	24.6	23.2	18.5	18.7	21.7	23.3	32.40	23.3
D	59.80	23.3	24.0	25.8	26.2	21.2	20.0	23.4	24.8	23.1	25.1	26.2	26.1	21.8	19.2	23.6	25.1	47.81	25.1
E	61.50	25.9	24.3	27.5	30.2	20.9	21.0	25.0	27.0	26.4	25.1	28.2	29.0	21.0	21.1	25.1	27.2	48.78	26.1
F	188.71	36.8	33.7	35.3	39.2	29.8	29.2	34.0	36.3	37.8	35.6	34.0	39.1	30.4	30.1	34.5	36.6	126.42	49.3
H	69.45	26.0	28.9	33.1	25.1	21.9	22.5	26.3	28.3	26.8	32.1	31.0	24.5	24.1	24.2	27.1	28.6	53.10	30.8
I	28.35	23.6	23.9	24.1	23.2	19.6	19.3	22.3	23.7	23.3	23.3	25.1	23.1	19.8	19.5	22.4	23.7	22.70	24.9
J	41.72	23.1	23.1	23.3	22.7	18.5	18.5	21.5	23.1	22.8	23.2	23.0	22.5	19.0	19.3	21.6	22.9	33.55	24.4
K	97.17	27.6	31.2	28.8	25.1	20.7	22.0	25.9	28.2	28.0	32.7	28.3	25.6	20.8	22.6	26.3	28.7	73.86	31.6
L	121.21	26.6	24.1	24.5	25.9	20.1	20.0	23.5	25.3	25.8	24.3	25.1	27.1	20.3	20.0	23.8	25.6	95.76	26.6
M	146.21	38.6	35.0	35.1	36.4	30.0	28.5	33.9	36.3	38.8	35.2	37.0	38.0	30.1	29.9	34.8	37.3	96.86	50.9

APPENDIX 8 – SUMMARY OF SOME KEY ATTRIBUTES

This appendix graphically summarizes some of the key attributes related to the shelf life of the MPB-killed Pl trees. These graphs are presented here as a summary of the data only – this is not an analysis or interpretation of the data. These graphs are presented in the same format as those given in the COFI report.[5] Detailed analyses of these data will be done by the CFS and others in subsequent projects.

Proportion of 5-m Logs with Different Numbers of Checks

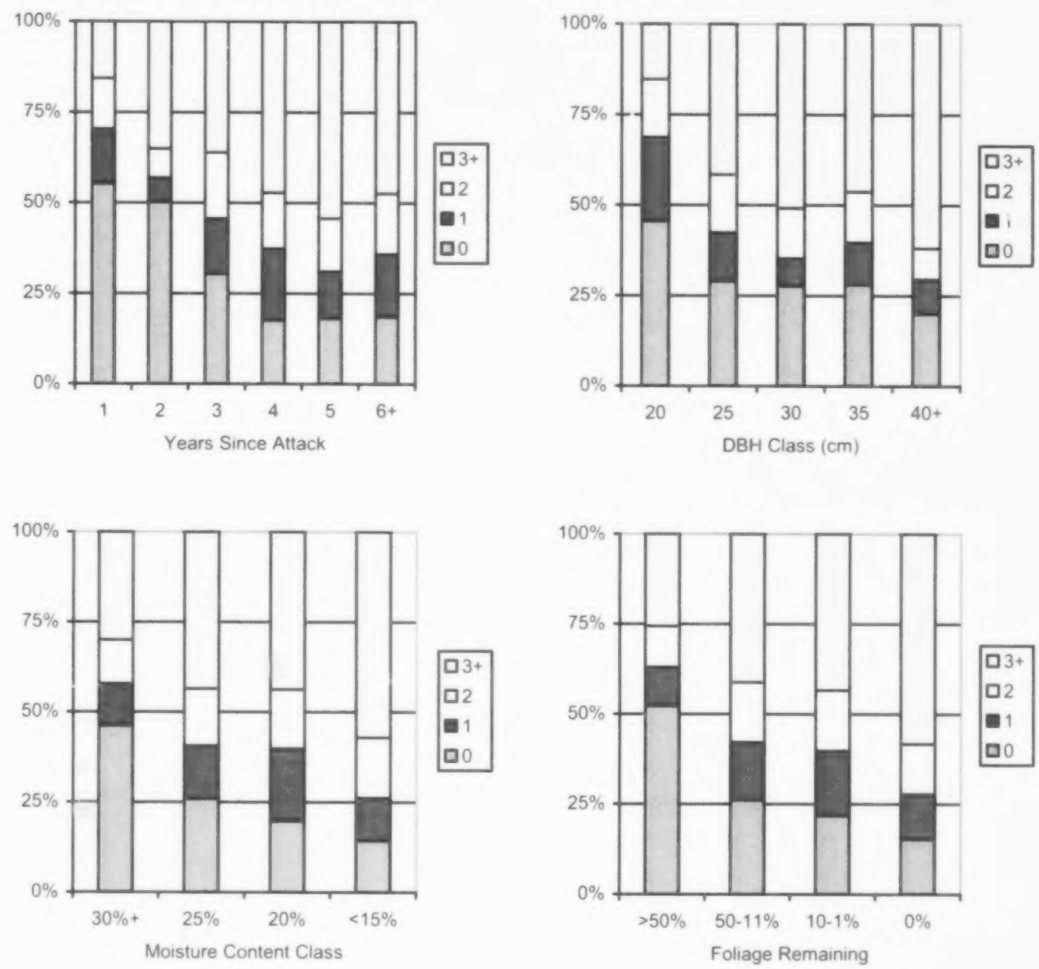


Figure 13. Proportion (%) of 5-m logs with 0, 1, 2, or 3+ checks related to various tree attributes.

Proportion of 5-m Logs with Different Numbers of Checked Log Quadrants

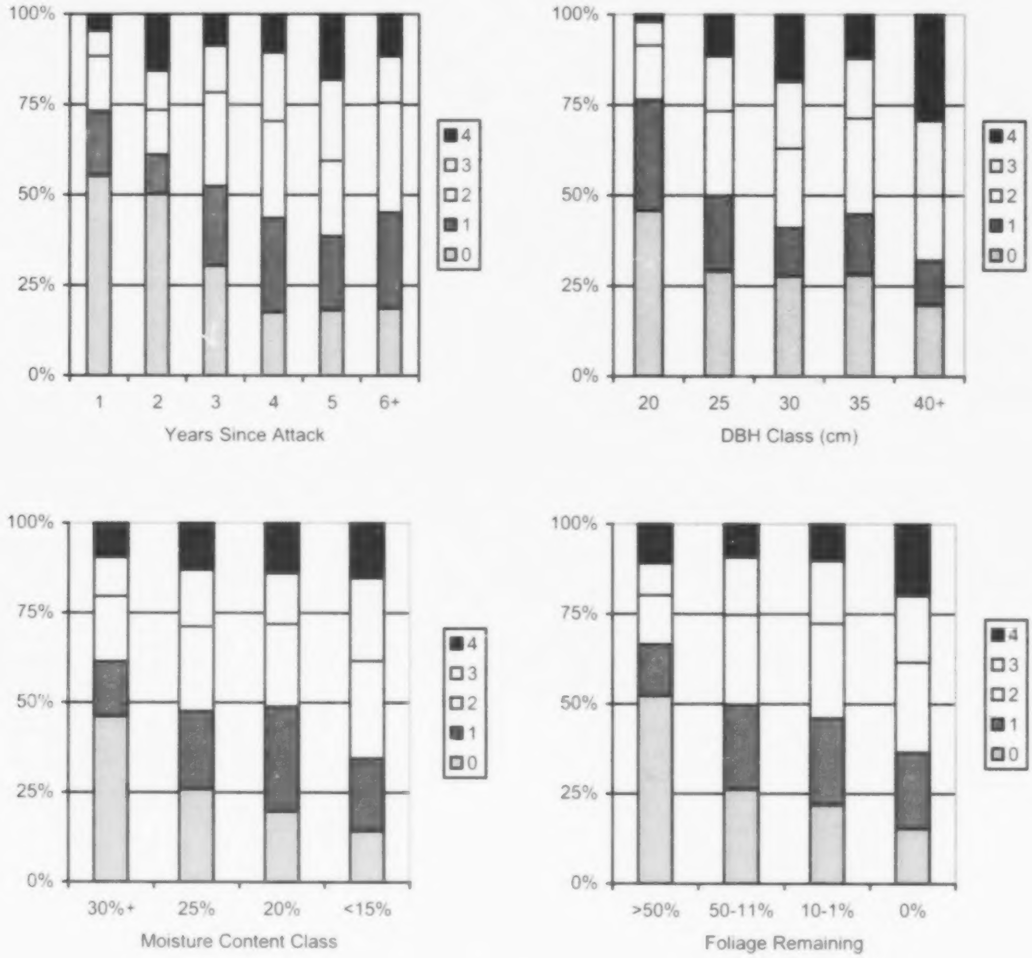


Figure 14. Proportion (%) of 5-m logs with checks in 0, 1, 2, 3, or 4 quadrants related to different tree attributes.

Proportion of 5-m Logs with Different Check Depth Classes

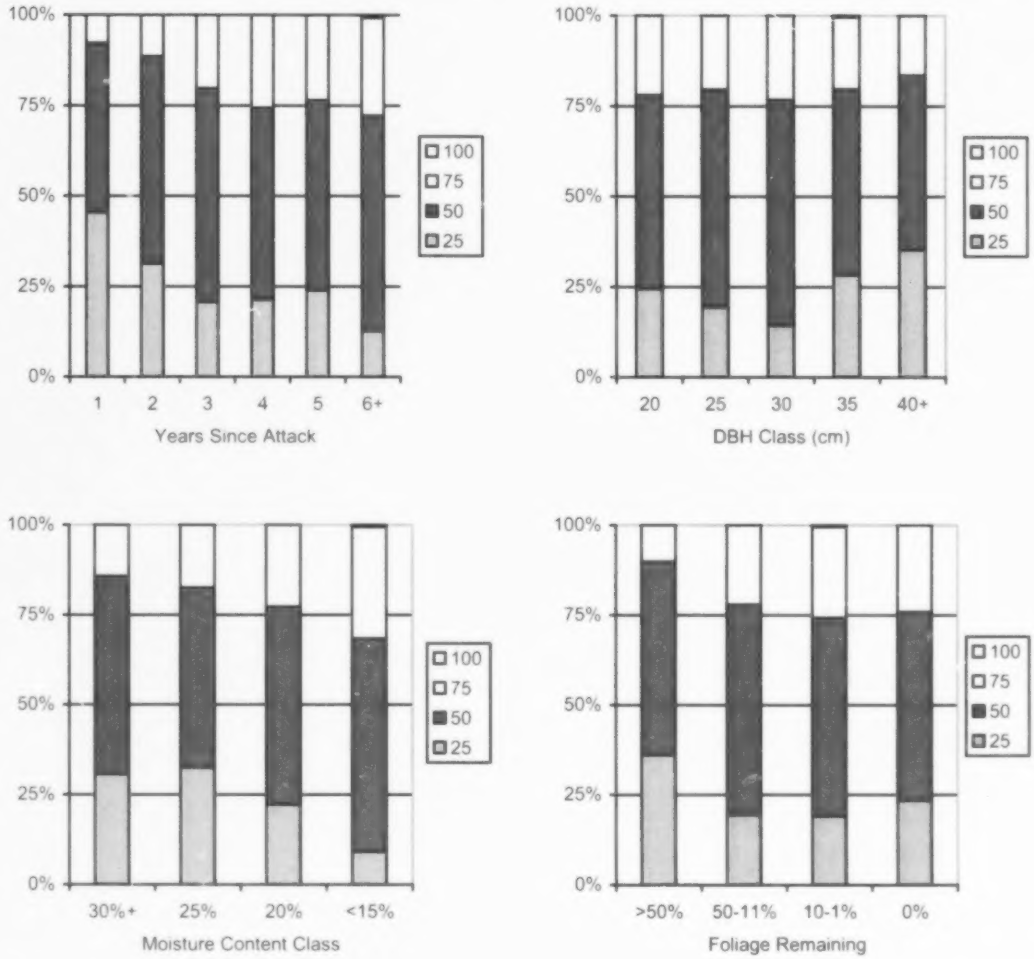


Figure 15. Proportion (%) of 5-m logs in different check depth classes (relative to log radius) related to different tree attributes.

Check Depth for 5-m Logs 1, 2, and 3

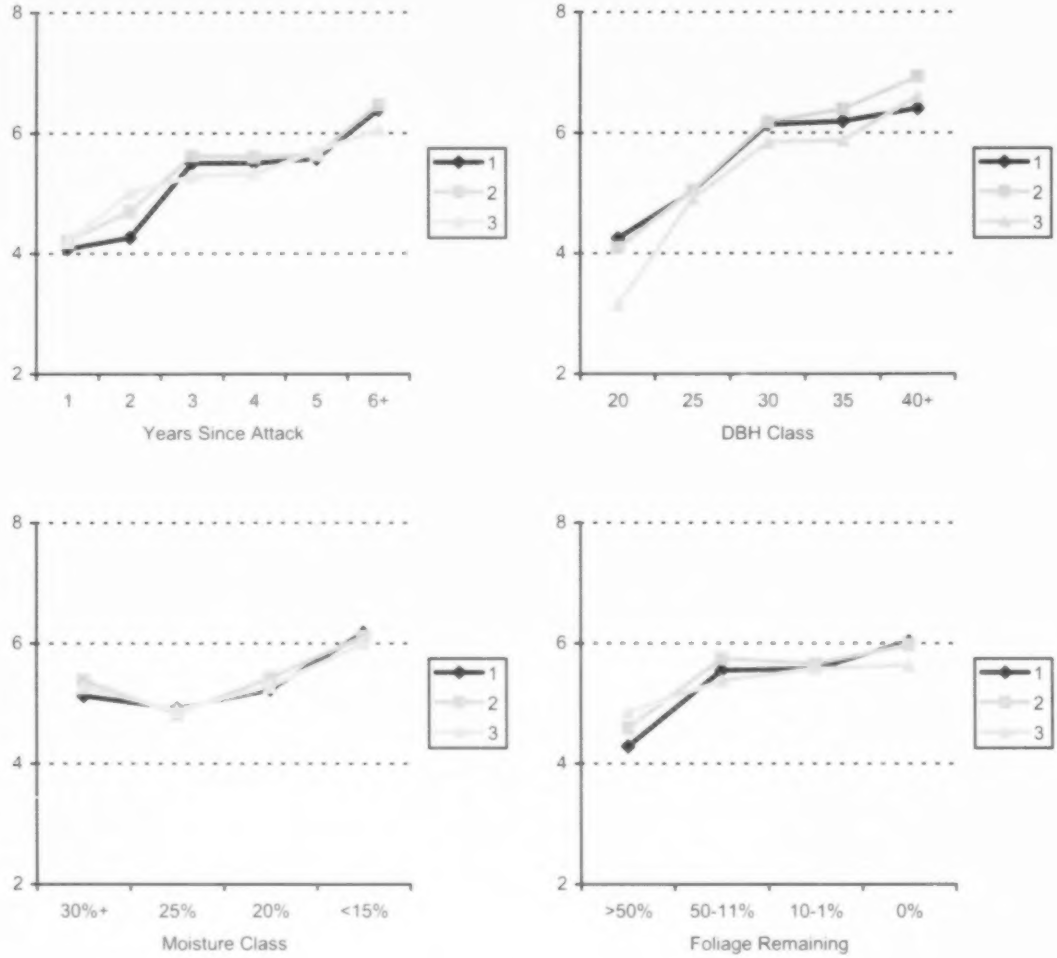


Figure 16. Depth (cm) of checks for the 5-m logs in positions 1, 2, and 3 related to different tree attributes.

Moisture Content for 5-m Logs 1, 2, and 3

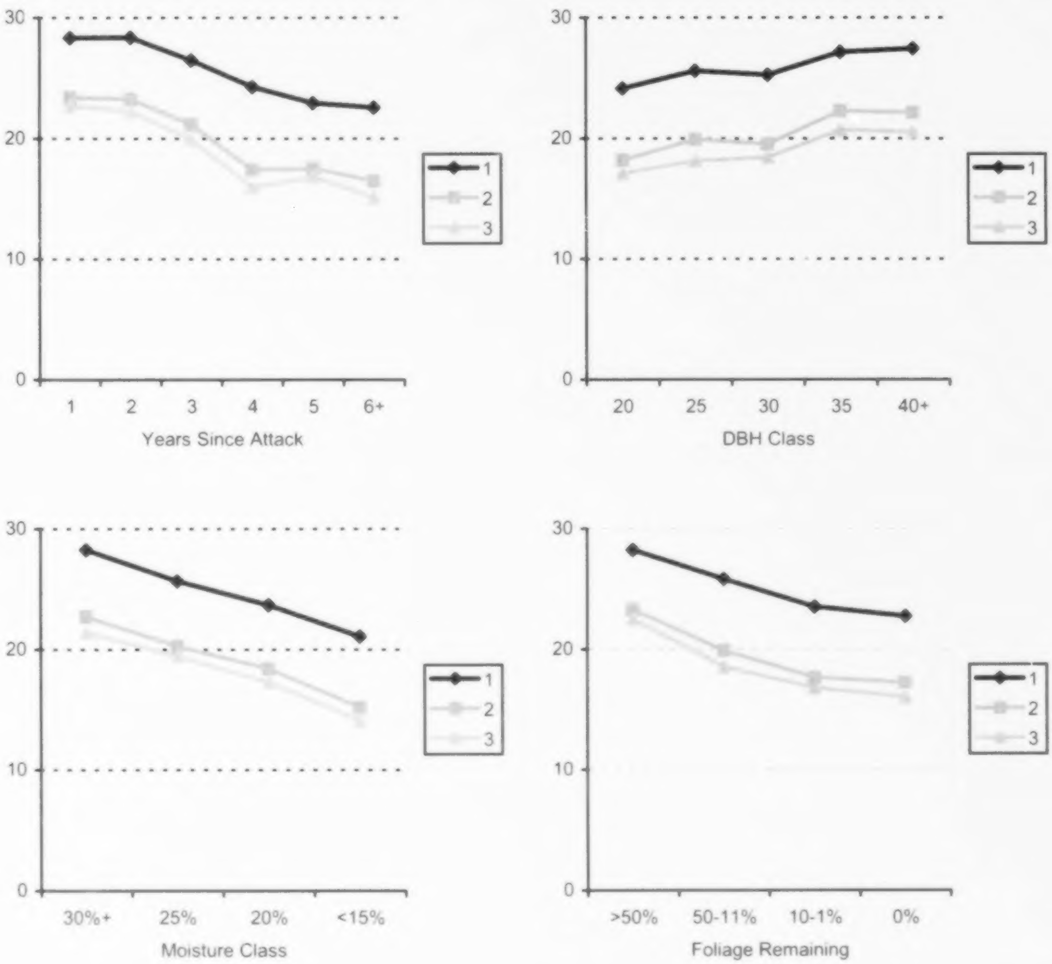


Figure 17. Average moisture content (%) for the 5-m logs in position 1, 2, and 3 related to different tree attributes.

Blue Stain for 5-m Logs 1, 2, and 3

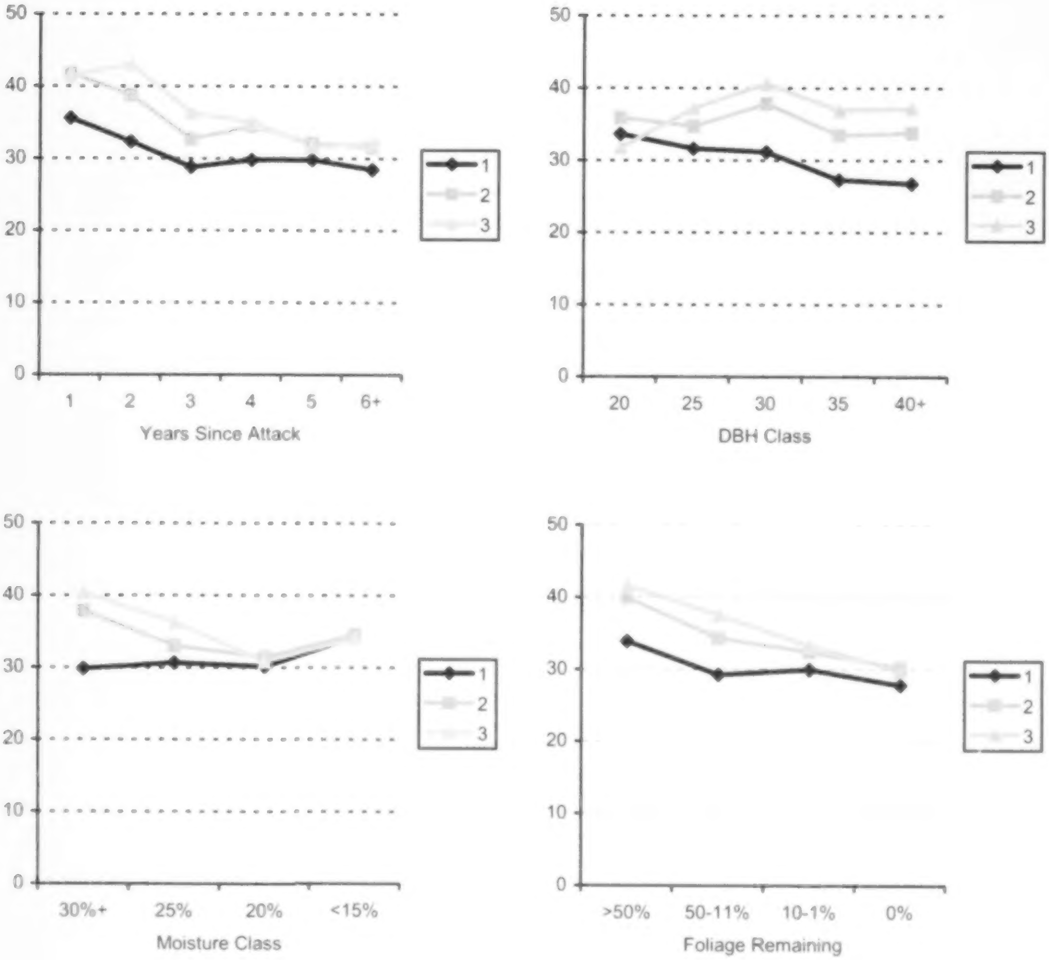


Figure 18. Proportion (%) of log volume with blue stain for 5-m logs in positions 1, 2, and 3 related to different tree attributes.

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